No. 15-1026

In the United States Court of Appeals for the Federal Circuit

LOKEN-FLACK, LLC
and
LYNN LOKEN

Plaintiffs-Appellants,

v.

NOVOZYMES BIOAG, INC.

Defendant-Appellee.

On Appeal from the United States District Court
For the District of Colorado case no. 1:13-cv-01617-MSK-BNB

BRIEF OF PLAINTIFFS-APPELLANTS

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CERTIFICATE OF INTEREST

Counsel for **Appellant** certifies that:

1. The full name of every party or amicus represented by me is:

   LOKEN-FLACK, LLC

   and

   LYNN LOKEN

2. The name of the real party in interest (if the party named in the caption is not the real party in interest) represented by me is:

   N/A

3. All parent corporations and any publicly held companies that own 10 percent or more of the stock of the party or amicus curiae represented by me are:

   None.

4. The names of all law firms and the partners or associates that appeared for the party or amicus now represented by me in the trial court or agency or are expected to appear in this court are:

   None.

Dated: October 21, 2014

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UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT
Number 15-1026

LOKEN-FLACK, LLC, a Colorado Limited Liability Company, and LYNN LOKEN, Plaintiffs,	)	CORPORATE DISCLOSURE
v.	)	
NOVOZYMES BIOAG, INC., a Delaware Corporation, Defendant.	)	

NOW COMES Loken-Flack, LLC, through counsel BLAKLEY JUSTICE, LLC and pursuant to Fed. R. App. P. 26.1 provides the following corporate disclosure: Loken-Flack, LLC has no parent entities and no publicly held entity owns ten percent or more of its stock.

Respectfully submitted this 8th day of December 2014.

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STATEMENT OF RELATED CASES

The following patent interference may be impacted by this court's decision. Likewise, the Patent and Trademark Appellate Board's decision may have an impact on this action:

Loken-Flack, LLC v. Novozymes Bioag A/S. Interference No. 105, 996, PTAB, U.S. Patent & Trademark Office, declared February 27, 2014.

JURISDICTIONAL STATEMENT

The district court had jurisdiction over this case pursuant to 35 U.S.C. § 256, and 28 U.S.C §§ 1331, 1338(a), and 2201. This Court has jurisdiction over this appeal pursuant to 28 U.S.C. § 1295(a)(1). Plaintiffs-Appellants timely filed the Notice of Appeal on October 7, 2014.

STATEMENT OF THE ISSUES

A. Whether the trial court misapplied the law of co-inventorship in finding Mr. Loken's contribution of the method necessary for conceiving the invention to be insignificant.

B. Whether the trial court misapplied the law on corroborating evidence in failing to take into account the accumulation of evidence, taken in the light most favorable to the non-movants and with all inferences made in their favor, in determining whether plaintiffs provided sufficient corroborating evidence to support Mr. Loken's claim of inventorship to survive summary judgment.

C. Whether the trial court erred in granting summary judgment to the defendant because it failed to take the facts in the light most favorable to the non-moving parties and make all inferences in favor of the non-moving parties, Lynn Loken and Loken-Flack, LLC.

STATEMENT OF THE CASE

Loken-Flack, LLC ("Loken-Flack") and Lynn Loken filed a Complaint against Defendant Novozymes BioAg, Inc. ("Novozymes") [1] on June 20, 2013 in the District of Colorado for the correction of inventorship of the United States Patent Number 8,357,631 ("the '631 Patent"). On October 28, 2013 Novozymes answered the Complaint.

The parties filed cross-motions for summary judgment on February 17, 2014. Each party filed responses and replies to those motions. The district court issued an opinion and order granting Novozymes' motion for summary judgment on October 1, 2014, holding that "the Plaintiffs have failed to come forward with any evidence

[1] Novozymes Bioag, Inc. ("Bioag") is a subsidiary of Novozymes BioAg A/S and is a Delaware corporation, having its principal place of business in the State of Wisconsin. The predecessors in interest of Novozymes BioAg A/S were Nitragin, Merck KGaA, and EMD Crop Bioscience Inc. For the purposes of clarity, this brief, adopting the convention of the trial court, A-4, n. 3, will refer to the Appellee at all times by the name "Novozymes," including substituting that name of "Nitragin" when quoting from exhibits.

that . . . would be sufficient to carry their burden under the heavy 'clear and convincing' standard." A-13.[2]

STATEMENT OF FACTS[3]

In 2001, two friends from Loveland, Colorado, Lynn Loken and Gary Flack, formed Loken-Flack, a Colorado limited liability company, to be the marketing arm of a manufacturer that sold organically derived colloids (ODC), a chitinous compound[4], under the brand name BEYOND™. A-52, A-160. Later the product was called YEA! A-160. Mr. Loken, an agronomist with many years of experience in the seed industry provided the expertise. A-52, A-160. ODC had never been a viable treatment in combination with other products because it had never before been available in the concentrations that Loken-Flack could provide. A-60, A-69. Prior to the chitinous product's availability through Loken-Flack, it could not be used effectively because "[i]t took tons of it to make any effect, and we can do it with minute quantities." A-57.

[2] Citations to the joint appendix use the convention "A-#."

[3] Taking the facts provided by Mr. Loken and Loken-Flack as true and making all inferences in their favor.

[4] Throughout this brief, the brand name BEYOND™ is used interchangeably with its description as an organically derived colloid, (ODC) a chitinous compound, also referred to as "chitosan." Likewise, the brand name OPTIMIZE® is used interchangeably with its description as a lipo-chitooligosaccharide (LCO).

Immediately after Loken-Flack's formation, Mr. Loken began exploring options of combining chitosan (ODC). with other products, to enhance plant growth and crop yield. A-54. Previously, it had been marketing ODC alone. This had not been done before, one of the reasons being the volume of chitinous material necessary to treat seeds or foliage, but after the development of ODC and BEYOND™, the treatment required smaller volumes of chitinous material. A-57. Mr. Loken developed a new protocol to treat seeds with BEYOND™ and other seed treatments using the concentrated product. A-82-85 and A-86-87.

Mr. Loken believed that combining Loken-Flack's seed treatment with other seed treatments, using a method and protocol he developed, would make a combination that was greater than the sum of the parts. A-54. In line with Mr. Loken's interest in combining ODC with other products, Gary Flack, on behalf of Mr. Loken, presented an Idea Submission Agreement to The Scotts Company, in September 2002 to combine ODC and Scotts Company's product, Miracle Gro, using Mr. Loken's protocol and method. A-82-85. During that same month, September 15, 2002, Loken-Flack entered into a confidentiality agreement and non-use agreement with Gustafson, LLC to test combinations of ODC with Gustafson products using Mr. Loken's protocol and method. A-86-87.

During 2002 and 2003, based on Mr. Loken's ideas and using his protocol and method, Gustafson tested ODC in combination with its product BioYield,

(abbreviated "BY"). A-88-96. In addition to BY, Mr. Loken also had an interest in combining ODC with Kodiak, another Gustafson product, using his method and his product. A-97.

In 2003, Loken-Flack came up with a list of companies it wanted to try to contact to establish a relationship for the testing of ODC, either as an individual application, or in a combination with a product sold by that company using Mr. Loken's protocol and its product, similar to what they had done with The Scotts Company and Gustafson. A-63, A-76. Since he had been aware of Novozymes while growing up on a farm, A-64, and based on Mr. Loken's interest in combining Novozymes' products with ODC as early as 2001 or 2002, A-64, in August 2003, he listed Novozymes as a possible company to contact. A-76. Loken-Flack listed John Hren as the contact for Novozymes. A-76.

Mr. Loken knew of a product, OPTIMIZE®, that Novozymes had been testing prior to introducing it into the market[5], and thought that using his method of combining ODC with other products and combining their product with OPTIMIZE® might provide the best synergy. A-219-221. The first contact at Novozymes, put Mr. Flack in touch with others at the company. A-98. Mr. Loken and Mr. Flack met with the Novozymes people in person and on the phone and eventually entered into a

[5] That is, over a year after Mr. Loken developed the protocol and method of an effective application of a chitinous material, Novozymes introduced OPTIMIZE® into the market, A-234-235.

testing agreement under which Loken-Flack would supply Mr. Loken's expertise, its materials and knowledge of its product and Novozymes would use its resources to test the combination. A-55, A-61, A-70-71. Novozymes later said it was doing this more out of curiosity than anything else. A-66, A-81. Mr. Loken worked with Novozymes throughout to suggest different concentrations of testing on the seeds. They even discussed applying for a joint patent. *See* A-65, A-78-79.

Novozymes had no prior knowledge and was unaware of both Loken-Flacks' ODC product and of Loken-Flack, A-60; *See also* A-69, until Mr. Flack, at the direction of Mr. Loken, contacted Mr. Hren, around 23 October 2003. A70-71. Loken-Flack proposed that Novozymes test ODC alone and in combination with Novozymes' product OPTIMIZE®, an LCO. A-70-71. Previously, Loken-Flack was told that Novozymes was producing components of Kodiak for Gustafson, a product Mr. Loken had been interested in combining with Loken-Flacks' ODC. A-97.

Novozymes is "a world leader in bio-innovation with over 6,000 patents." A-103. It markets over 700 biotechnology products in 130 countries and boasts 47% of the global market share in enzyme production alone. A-186.

Novozymes claims that current employee, Stewart Smith, and former employee, Robert Osborn, jointly conceived the combination of LCO and chitinous compounds, by no later than October 2003, while working together at Novozymes. A-124. Loken-Flack disputes this claim as, at the suggestion of Mr. Hren at

Novozymes, Loken-Flack prepared a new list prior to 15 December 2003, where Mr. Flack substituted Mr. Hren's name with Mr. Smith and wrote "OPTIMIZE®" on the list. A-64. *See also* A-77. Additionally, Loken-Flack claims that Mr. Hren informed Mr. Smith of a phone call he received from Mr. Flack in October 2003, where Mr. Hren referred Mr. Flack to Mr. Smith. A-124, A-60-70. In any event, because neither Mr. Smith nor Mr. Osburn knew of Mr. Loken's method of applying a chitinous material, nor of the existence of a chitinous material that could be applied effectively, A-60, 69, their combination was not a conception of the invention disclosed in the '631 Patent.

Interestingly, the list of publications on the résumé of R. Stewart Smith seems to have been modified after the fact to support a fabrication. It proceeds chronologically with items 1 – 52, through 1999. Item 53 is inserted referencing the '631 patent not issued until 2013, followed by item 54, an undated publication on LCO co-authored with Mr. Osburn. Presumably, the reader of the list is to believe that this undated publication was written prior to the next item, 55. Item 55 with a 2003 publication returns to the previous chronological order and carries through to a 2014 publication in item 70. The awkward placement of items 52 and 53 are of particular note given this litigation. A-199-207, esp. A-206.

On March 19, 2004, Mr. Flack memorialized his prior contacts with Novozymes, in which he reports that in his first phone call, he had reported to Mr.

Hren about the method and protocol that Mr. Loken had developed and used previously with Gustafson, reporting the "good results we had with [combining] our product and Rhizo at Gustafson on tomatoes." A-79, *see* A-91. In a second telephone conversation with Novozymes, this time with Mr. Smith, Mr. Flack reported that Mr. Smith confirmed that OPTIMIZE® was the leading candidate for a Rhizo from Novozymes to be combined with ODC using Mr. Loken's method and protocol. A-78-79, *see* A-124. At which point, in March 2004, a Mutual Confidential Disclosure Agreement between Novozymes and Loken-Flack was entered. *See* A-124.

The following month, April 2004, Mr. Loken contacted Mr. Smith, to discuss Mr. Loken's, Loken-Flack's, Novozymes', and Mr. Smith's joint "interest in having a 'position' by applying for a joint patent covering the use of ODC and" other products using Mr. Loken's method and the concentrated chitinous compound. *See* A-65, A-78. Then, Loken-Flack worked with Novozymes for several years in an attempt to create a marketing agreement on the combination of the ODC, BEYOND™, and OPTIMIZE®, using Mr. Loken's method and protocol and the concentrated product. This agreement never came into fruition. A-62. Disappointed, Loken-Flack focused on other seed treatment ventures. Unbeknownst to Loken-Flack, however, Novozymes applied for a patent without naming Mr. Loken as an inventor. A-41. Mr. Loken learned of this duplicitous behavior after the patent application was published. A-211. The data included in the '631 Patent,

was data developed during tests of the Loken-Flack and Novozymes products using Mr. Loken's protocols and methods. A-55.

The two men from Loveland, Colorado found they had been victims of this all-too-common story – a multinational corporation leading individuals on, then after acquiring all their expertise, telling them that nothing could come of it, while planning to exploit the fruits of the little guys' labor. A-165. As Mr. Loken noted during his deposition "it looks like they [Novozymes] went around us." *See* A-165. The United States Patent and Trademark Office issued the '631 Patent, U.S. Patent 8,357,631, on January 22, 2013. A-41.

Mr. Loken and Loken-Flack brought suit in the District of Colorado for correction of inventorship of the '631 Patent in order to remedy an injustice and protect its business interests against Novozymes. The trial court granted summary judgment to Novozymes and the Plaintiffs timely appealed.

SUMMARY OF THE ARGUMENT

Novozymes sought summary judgment under two bases. The first was that Mr. Loken could not have invented a combination of one lipo-chitooligosaccharide ("LCO") with one or more chitinous compounds because he did not fully understand the chemical composition of LCOs. The second was that Mr. Loken failed to provide corroborating evidence of his inventorship.

The district court misconstrued Mr. Loken's contribution to the conception of the invention. It held in essence that only if Mr. Loken could understand the chemical make-up of each of the two compounds could he be an inventor of a product that simply combined the two. However, the law does not require that each inventor know everything about each element of each claim, nor does it require that when one is interested in combining two compounds, one need know anything about the chemical composition of either. Rather than conceiving of combining his chitinous product with a particular LCO product to obtain a synergistic effect, Mr. Loken's unique and significant contribution to the invention was to engage in independent testing and research to develop a protocol and method of combining a novel ODC product with other products such as LCOs to create a synergy not present with any product alone and unavailable and unknown prior to Loken-Flack's method of concentrating its chitosan. A-54, A-57, A-76-85, A-89-98.

Although Novozymes claims its employees conceived of the combination of ODC and LCO before October of 2003, they did not believe it would be fruitful, A-66, A-80-81, because they had no notion that a chitinous product could be made in such concentrations that the product could effectively be combined with other products and applied to seeds as a seed treatment – the very method that Mr. Loken and Loken-Flack provided, that Mr. Loken had developed before October 2003. A-57.

Moreover, the district court reached its conclusion based upon a flawed application of the law of corroborating evidence of co-inventorship. While corroborating evidence beyond testimony must be provided by the person wishing to be added as a co-inventor, *Ethicon, Inc. v. United States Surgical Corp.*, 135 F.3d 1456, 1460, (Fed. Cir. 1998), the pertinent evidence must be reviewed in its entirety and circumstantial evidence about the inventive process may accumulate and corroborate. *Id*. The trial court improperly failed to acknowledge the accumulation of evidence supplied by Mr. Loken and Loken-Flack, A-5, A-44-46, A-53-54, A-57-58, A-61, A-66, A-78-98, but instead found that none of the corroborating evidence alone was "sufficient to carry their burden . . . by clear and convincing evidence." A-12-13.

Finally, the district court erred in granting summary judgment to Novozymes because it failed to view the facts in the light most favorable to Mr. Loken and Loken-Flack, the non-moving parties, and make all inferences in their favor. If anything, the trial court took the evidence in the light most favorable to the movants and made inferences in the movants' favor. The court stated, for example, that one piece of plaintiffs' corroborating evidence "does not refute the *possibility* that Drs. Smith and Osborne independently conceived of a potential synergistic effect between LCO and ODC." A-12 (emphasis added). When, instead, the evidence on the record is viewed in the light most favorable to Mr. Loken and Loken-Flack, a

fact-finder could determine that they indeed demonstrated by clear and convincing evidence that the information they gathered from independent tests with Gustafson and Scott, A-79-87, A-90, A-92-98, as well as the method and protocol Mr. Loken invented were a substantial contribution to the conception of the synergistic effect of combining BEYOND™ and OPTIMIZE®.

STANDARD OF REVIEW

This Court reviews a district court's grant of summary judgment *de novo.* Summary judgment is proper only where "there is no genuine issue of material fact and . . . the moving party is entitled to judgment as a matter of law." Fed. R. Civ. P. 56(c). The party opposing summary judgment may defeat it "by demonstrating a genuine issue of material fact through, among other means, depositions and answers to interrogatories." *Klingele v. Eikenberry,* 849 F.2d 409, 413 (9th Cir. 1988), citing *Celotex Corp. v. Catrett,* 477 U.S. 317, 325, 106 S. Ct. 2548 (1986). All inferences are to be drawn in the non-movant's favor. *Matsushita Elec. Indus. Co. v. Zenith Radio Corp.,* 475 U.S. 574, 586-87, 106 S. Ct. 1348, 1355-57 (1986).

Inventorship is a question of law, which this Court also reviews *de novo. Ethicon,*135 F.3d at 1460. Thus, if the district court "'engaged in a faulty legal analysis in applying the law to the facts and a correct application of the law to those facts might bring a different result,"' reversal of a summary judgment decision on inventorship "is required." *Beech Aircraft Corp. v. EDO Corp.,* 990 F.2d 1237, 1245,

26 USPQ2d 1572, 1579 (Fed. Cir. 1993) (citation omitted). This Court held that one seeking to correct inventorship must prove its case by clear and convincing evidence. *Nartrn Corp. v. Schukra USA Inc.*, 458 F.3d 1352, 1356 (Fed. Cir. 2009).

ARGUMENT

1. The Trial Court Misapplied the Law of Co-Inventorship

The law of inventorship as set forth by this court "sets no explicit lower limit on the quantum or quality of inventive contribution required for a person to qualify as a joint inventor . . . a joint invention is simply the product of a collaboration between two or more persons working together to solve the problem addressed." *Fina Oil & Chem. Co. v. Ewen*, 123 F.3d 1466, 1473 (Fed. Cir. 1997) (citation omitted). "[F]or the conception of a joint invention, each of the joint inventors need not 'make the same type or amount of contribution' to the invention . . . Rather, each needs to perform only a part of the task which produces the invention." *Ethicon*, 135 F.3d at 1460. Moreover, "Conception is complete when the idea is so clearly defined in the inventor's mind that only ordinary skill would be necessary to reduce the invention to practice." *Burroughs Wellcome Co. v. Barr Labs Inc.*, 40 F.3d 1223, 1228 (Fed. Cir. 1994).

While this court has held that "the inventors as named in an issued patent, are presumed to be correct," *Nartrn*, 458 F.3d at 1356, inventorship may be corrected when an inventor has been omitted. 35 U.S.C. § 256. The burden on the omitted

inventor is a "heavy burden of proving its case by clear and convincing evidence." *Nartrn*, 458 F.3d at 1356. The burden is not insurmountable.

In one case, the court set out three elements that a joint inventor must prove, see *Pannu v. Iolab Corp.*, 155 F.3d 1434, 1451 (Fed. Cir. 1998). In later cases, even when citing to the *Pannu* case, the Court has conflated the standard to showing that a co-inventor contributed to the conception in a significant way. *Bard Peripheral Vascular Inc. v. W L Gore & Assoc. Inc.*, 670 F.3d 1171, 1180 (Fed. Cir. 2012).

In *Bard*, the Court was reviewing a trial court's jury verdict that the alleged co-inventor had not contributed significantly to the conception. The Court held that the proposed co-inventors' "lack of understanding of what would make a successful graft is substantial evidence in support of the jury's verdict, implicitly finding that Cooper's contribution was insignificant." *Id*. at 1180-1181. Apparently Mr. Cooper simply provided some samples of tubing without any indication of how it should be used or how it would contribute to the final product. While the court held that Mr. Cooper was not a co-inventor, the dissent was clear that the law of this Circuit did not support the majority's conclusion.

The dissent in *Bard* could have been writing about this case when Judge Newman wrote that the court held "that a person who performs the requested test of a material that is provided to him for testing for a specified use, can then, when the

test is successful, patent the material he was provided, for the use for which it was tested." *Id* at 1190 (Newman dissenting).

In this case, Mr. Loken and his company, Loken-Flack, provided much more than the majority required in *Bard*. Mr. Loken and Loken-Flack engaged in independent testing and research and developed a protocol and method of combining its novel product, with others, to create a synergy not present with any product alone. A-54, A-82-97. They created a protocol or method of using their product, BEYOND™, in combination with other products. A-82-97. Subsequently they supplied their product and explained their method, suggesting that their product be combined using their method with Novozymes' product to create a synergy and a new compound. A-76. Along with Novozymes, they designed a test for a specified use. A-61, A-66, A-78-81, A-91. When the test was successful, Novozymes attempted to acquire a patent without naming Loken or Loken-Flack for their contribution of a method and the combination of the ODC and LCO. A-55, A-62, A-210-218, A-165. Loken-Flack's independent testing evidences much more than the conventional use of its product alone. Rather the combination with other products containing rhizobacteria, and a method of combining the BEYOND™ with other products, produced a synergistic effect. The protocol and method were unavailable prior to this time because the chitosan product was not in a sufficiently concentrated form before Loken-Flack's involvement with BEYOND™. A-5, A-57-58, A-61.

The patent-in-suit itself admits that the named inventors did not know of the concentrations. A-44-46.

When the facts are taken in the light most favorable to Mr. Loken and Loken-Flack, the non-moving parties, it is clear that Mr. Loken's contribution was quite significant. He and Loken-Flack were involved in independent testing of the unique product, BEYOND™, and deploying a method for combination not available prior to Loken-Flack's method of concentrating its chitosan. A-54, A-57, A-82-97. The people at Novozymes had no notion that a chitinous product could be made in such concentrations that the product could effectively be combined with other products and applied to seeds as a seed treatment. A-57. Mr. Loken knew of Novozymes and its product, even though Novozymes' product was in testing prior to Mr. Loken's contacting Novozymes, A-64, A-69, and by Novozymes own admission, it suggested its productive OPTIMIZE®, as the leading candidate to be combined with BEYOND™, after Mr. Loken's agent contacted Novozymes suggests the use of Mr. Loken's protocol, to use a limited amount of the concentrate or to combine it with other products. A-78-79, A-91. The parties executed a confidentiality agreement and a testing agreement showing again their intent to work together to collaborate on a new product. A-124, A-5.

Additionally, they discussed applying for a joint patent, A-78, and Mr. Loken arranged for the scientists at Novozymes to contact a scientist at Colorado State

University so that the scientists at Novozymes could understand the chemical composition and properties of its product, BEYOND™, and could verify that Mr. Loken's method of applying his product in combination would be efficacious. A-78. Moreover, Mr. Loken put Novozymes in contact with another company with whom Mr. Loken had successfully practiced the method of combining his chitosan with another product years before his first contact with Novozymes. A-80-81.

The facts of *Falana v. Kent State Univ.*, 669 F.3d, 1349 (Fed. Circ. 2012) are remarkably similar to the facts of this case. In that case, *Falana* created a protocol to synthesize a compound, entitled Compound 7, *Id*. at 1352, 1353. "Compound 7 was a 'great improvement' and represented 'significant progress,' but did not completely satisfy the goals of the project." *Id*. at 1353. Compound 7, in the *Falana* case, is analogous to the compounds that Mr. Loken created with Scotts and Gustafson. A-82-97. The synergy from the combination of those two products, using his protocol, was not as great as would be desired, similar to the Compound 7 in *Falana* case. *Id*. In the *Falana* case a new compound, Compound 9, was created that provided the proper synergy. The people who used *Falana's* protocol to create Compound 9, filed for a patent without naming *Falana* as an inventor.

Similarly, using Mr. Loken's protocol developed with testing that he performed with Scotts and Gustafson, A-82-97, Novozymes and Mr. Loken created a combination of the chitinous product and their LCO product and filed for a patent

without Mr. Loken's being named as an inventor. A-41-51. Just as in *Falana* where "the patent specification discloses the synthesis protocol developed by Falana as the protocol utilized to synthesis the claimed class of chiral compounds" *Id*. So in this case, claim 21, A-51, includes the protocol developed by Mr. Loken and first tested with Scotts and Gustafson, long before contact was ever made with Novozymes.[6]

And why was the protocol so novel? Because prior to Loken-Flack's having a chitinous product that could be used in low concentrations, no one would even attempt to use gallons and gallons of chitinous product to treat seeds. A-57. After the method using Loken's skill to treat seeds with less volume of the chitinous product, he could develop the protocol to apply the chitinous product along with other products. He used that protocol with Scotts and with Gustafson and finally disclosed it to Novoymes. A-61, A-66, A-69-71, A-78-81, A-91, A-124.

This case differs from *Falana* in two respects. First, in the *Falana* case, because a new chemical was being disclosed it was necessary that Falana understand the chemical structure of the compound. *Id*. at 1357. In Mr. Loken's case, it is not necessary for him to understand the chemical composition of either compound in that he was simply applying two compounds to a seed.

[6] As the Court is aware, "a co-inventor need not make a contribution to every **claim** of a patent. *See* 35 U.S.C. § 116. A contribution to one **claim** is enough." *Ethicon, Inc. v. U.S. Surgical Corp.*, 135 F.3d 1456, 1460 (Fed. Cir. 1998).

In both *Falana* and *Fina* a new chemical was being invented. *See Fina*, 123 F.3d at 1473. But in this case, one need not know the chemical formula of either compound, BEYOND™ or OPTIMIZE®, to make a substantial contribution of a combination of the two. As *Fina* said "if a person supplies the required quantum of inventive contribution, that person does not lose his or her status as a joint inventor just because he or she used the services, ideas, and aid of others in the process of perfecting the invention." As in the *Fina* case, the district court's requirements on Mr. Loken "effectively required [him] to show that he was the sole inventor of the" patent. *Id*. at 1474. Of course, Mr. Loken does not claim he was the sole inventor, rather that he was a co-inventor by supplying a significant contribution and following through throughout the period of the agreement.

The essence of the trial court's holding was that only if Mr. Loken could understand the chemical make-up of each of the two compounds, then could he be an inventor of a product that simply combined two compounds. However, the law does not require that each inventor know everything about each element of each claim, *Ethicon*, 135 F.3d at 1460, nor does it require that when one is simply interested in combining two compounds, one need to know anything about the chemical composition of either compound. *See, e.g., id.* at 1458 (where none of the co-inventors is said to know how the computer based message system worked). Based upon Loken-Flack's independent testing of combinations of its products with

other products (when it may or may not have known the chemical composition of those products), and development of a protocol, Mr. Loken proposed a combination of two compounds and a method previously unknown to Novozymes to combine them. A-54, A-57, A-82-97.

In *Ethicon*, the invention was a probe that, after passing through dense human tissue, would send a message to the surgeon so that the surgeon would not inadvertently stab less dense tissue, such as an internal organ. *Ethicon*, 135 F.3d at 1458. There was no evidence that either inventor knew how this message would be sent, nor did they need to. If the invention in the patent-in-suit had been the invention of a chemical formula, it would make sense that the inventors would need to know the composition of all of the chemicals involved, see *Fina* 123 F.3d at 1473, but that is not the case.

In *Ethicon*, the plaintiff sued for correction of inventorship and this Court held that the invention "may be the work of two or more joint inventors of" whom one is not as technically savvy as the other. *Id.* at 1460. Furthermore, "each of the joint inventors need not 'make the same type or amount of contribution' to the invention." *Id.* (citation omitted). They need not be physically working together. *Burroughs Wellcome*, 40 F.3d at 1227.

Moreover, in *Falana* there was no method claim in the patent. In spite of the lack of a method claim, the court held that only by using Falana's method could

Compound 9 have been created. *Id*. at 1357, 1358. The court in *Falana* held that "Falana's lack of contribution to the discovery of Compound 9 itself, does not negate his contribution of the method used by the other inventors to make the genus of compounds covered by the claims at issue." *Id*. at 1359.

The patent-in-suit does include a method claim. A-51. Mr. Loken at least conceived Claim 21 is " [a] method for enhancing plant growth or crop yield comprising administering to a plant or seed a composition comprising at least one [LCO] and one or more chitinous compounds selected from the group consisting of chitins and chiosans in an effective amount for enhancing plant growth or crop yield." A-51.[7] Even if the standard for summary judgment were to take all of the evidence in the light most favorable to the *moving* party, the *Falana* case shows that Mr. Loken is an inventor. Even if taking the untested statements of Stewart Smith to be true that he and Robert Osborn had the idea of combining chitinous products with LCO's before their first contact from Loken through his agent, Mr. Flack, they could not do it until Mr. Loken supplied the proper method for combining the two products. Just as in *Falana*, where Compound 9 could not have been created until Falana contributed the method, in this case the combination of chitinous products with

[7] Since to survive summary judgment and to be a co-inventor, Mr. Loken need only be an inventor as to one or more claims, all of the dependent method claims of which he is also an inventor are not set forth in this brief.

LCO's to enhance plant growth or crop yield could not have been created until Mr. Loken and Loken-Flack contributed the method.

Furthermore, the trial court completely ignored the agreements between Novozymes and Loken-Flack. A-5. Taking the evidence in the light most favorable to Loken-Flack and Mr. Loken, and making all reasonable inferences in the non-movants' favor, the Court should have inferred that there would be no reason to have a joint agreement if there were no value in Mr. Loken's continued contribution to the inventive process.

Mr. Loken had identified that the independent testing demonstrated an advantage to him in combining products including rhizobacteria and a method of combining the products as described in the patent to enhance plant growth or crop yield. He knew that prior to his creation of a protocol to apply his concentrated product, no effective combination could occur. A-57. He described this protocol and synergy with particularity and engaged in independent testing with combinations with other products. A-54, A-82-97. He tested with different concentrations of his product and finally contacted Novozymes after he inquired about products that contained the same effective ingredients as the Novozymes product. A-76.

Mr. Loken believed his protocol of combining his BEYOND^{TM} would create a synergy. A-76. He endeavored to do independent testing with his product and others' products, A-54, A-82-97. He tested his protocol and idea with Scotts and

Gustafson and received encouragement. A-82-97. He did not know whether combining Novozymes' OPTIMIZE® and BEYOND™ would provide the required synergistic results. But, he knew Novozymes couldn't do it without BEYOND™ and his method. A-57. Mr. Loken knew that his company did not have the resources to test the product itself and would require an agreement with Novozymes to conduct the testing. A-55.

"An inventor need not know that his invention will work for conception to be complete." *Burroughs Wellcome* 440 F.3d at 1228. Based upon his previous testing and the previous test results he had an inclination that the result would be favorable. A-70-71. However all he needed was "a specific, settled idea, a particular solution to the problem at hand, not just a general goal or research plan . . . the conception analysis necessarily turns on the inventor's ability to describe his invention with particularity." *Id*. Mr. Loken described his invention with particularity, that is, combining his chitinous product with another known material. S*ee* claims 1 and 21 of the patent. A-50, A-51. Mr. Loken described his protocol using BEYOND™; previously inconceivable to Novozymes because they did not know of Mr. Loken's method with a new concentrated product. A-57, A-60, A-69. At no time has Novozymes claimed they knew of the concentrate. The named inventors claim they thought to combine a chitin with their LCO before contact with Loken-Flack. A-124.

However, they never claimed they knew of any concentrate or of BEYOND™ in particular or any method to combine effectively[8].

Even if the facts are taken in light most favorable to the *movants*, as the trial court appeared to do, Mr. Loken is still a joint inventor. Stewart Smith, one of the named inventors, alleges (without providing any corroboration or other evidence, see *order* at 4, A-5), that he conceived the combination prior to contact with Mr. Loken or his partner in Loken-Flack. Mr. Smith admits however, that he did not believe it would be fruitful, A-66, A-80-81, because he did not know of the method Loken-Flack used to manufacture BEYOND™, or a method of using a manageable amount of the chitinous material. A-57. Nor did he know what percentages of concentration to use, he only learned of this in collaborating with Mr. Loken. A-61. Consequently, Smith's alleged invention could not be conceived without extensive research or experimentation or without Mr. Loken's contribution, which was significant. *See Burroughs Wellcome*, 40 F.3d at 1228.

Mr. Loken provided substantial contribution to the invention in at least one claim of the patent-in-suit. Based upon previous testing of combinations of compounds, he proposed a combination of two compounds, his BEYOND™ and

[8] There is no requirement that a named inventor come forth with any evidence of invention. In most cases, however, they provide some evidence. In this case, the named inventors have provided nothing but their unsubstantiated self-serving declarations.

LCO and discovered a previously unknown method of combining them. A-54, A-57, A-82-97. This invention could not be made without Mr. Loken's contributions. Novozymes' named inventors did not know of BEYOND™ prior to this time, A-60, A-69, nor did they know of the concentrations of the chitinous material available. A-57. Without this substantial contribution and without Mr. Loken's continued contributions during the term of the agreements between the parties, A-5, A-60-62, A-78-82, A-91, A-124, the invention could not have been created. As the court said in *Burroughs Wellcome*, without the Mr. Loken's contribution the invention could not have been conceived without "extensive research or experimentation." *Burroughs Wellcome* 40 F.3d at 1228. Mr. Loken is an inventor.

2. Mr. Loken and Loken-Flack Provided Sufficient Corroborating Evidence as to Mr. Loken's Inventorship to Survive Summary Judgment

Because inventorship is presumed to be correct in patent issues, corroborating evidence must be provided by the person wishing to be added as a co-inventor, *Ethicon* 135 F.3d at 1461. However, the pertinent evidence must be reviewed in its entirety and circumstantial evidence about the inventive process may accumulate and corroborate. *Id*. Generally, one piece of evidence will be insufficient to corroborate but corroboration may be an accumulation of many pieces of evidence. "Whether the inventor's testimony has been sufficiently corroborated is evaluated under a 'Rule of Reason' analysis." *Trovan LTD v. Sokymat SA*, 299 F.3d 1292, 1302

(Fed. Cir. 2002). While that Court held that corroboration preferably is from contemporaneous records, circumstantial evidence may also corroborate. *Id.* at 1302 – 1303. All the evidence need not be documentary but may be from other sources or may be inferences from documents. For instance, in *Ethicon*, 135 F.3d at 1464 (Fed. Cir. 1998), this Court looked at eight pieces of information as corroboration, some documentary, some from facts, some inferences:

> (1) Yoon's need for a person with expertise in electronics; (2) Choi's background in electronics, (3) Yoon's proposal that he and Choi should work together to develop new products, including safety trocars, (4) their informal business relationship, (5) the length of time they worked together, (6) the absence of any pay to Choi for his work, (7) the similarity between Choi's sketches and the patent figures, and (8) the letter in which Choi stated that he could no longer be a "member" of Yoon's business.

Id. While no one piece of evidence was sufficient in *Ethicon*, all of the evidence together corroborated Choi's claim that he was a joint inventor.

The trial court, in this case, found that "none of the corroborating evidence supplied by the Plaintiffs is sufficient to carry their burden of showing, by clear and convincing evidence, that Mr. Loken was the first to conceive of the idea of combining an LCO and a chitin." *Order* at 11-12. A-12-13. The Court is correct, as

in *Ethicon*, **no one piece** of the corroborating evidence **alone** is sufficient. However, when taken in the light most favorable to the non-movants, Mr. Loken and Loken-Flack, and when all inferences are made in their favor, the accumulation of evidence is more than sufficient to survive summary judgment.

The parallels to *Ethicon* are striking:

> (1) Novozymes needed someone with expertise in manufacturing chitinous products in concentrations that were able to be applied, A-57; (2) Mr. Loken's background in combining his chitin product with other products, A-54, A-92-97; (3) Novozymes' proposal that it work together with Plaintiffs to develop and test the combination, A-61, A-64, A-77-79, A-91, A-124; (4) their ***formal*** business relationship, A-5, A-124; (5) the length of time they worked together, A-61-61, A-78-79, A-91, A-97, A-124; (6) the absence of any pay to Plaintiffs for their work; (7) the identity of the test results and the results listed in the patent, A-55; (8) the email in which Mr. Loken suggested pursuing a patent application as joint inventors with no objection received from Novozymes. A-65, A-78-79.

In fact, the evidence, after making all inferences in favor of Mr. Loken and Loken-Flack, is stronger than in *Ethicon*. In *Ethicon*, for instance, there was an

informal relationship, whereas in this case the relationship had been formalized. A-5, A-124. In *Ethicon*, there was a letter terminating the relationship. In this case, there was an email, not followed by a disputation from a named inventor that he, Stewart Smith, had approached Mr. Loken about applying for a joint patent. A-78.

The trial court failed to acknowledge this accumulation of evidence. First, Novozymes did not have anyone with expertise in manufacturing chitinous products in concentrations that were able to be applied to seeds. A-57. Neither named inventor had any notion of the method that Mr. Loken had tested previously to combine a chitin in acceptable concentration. A-57. It was necessary for Mr. Loken to propose the combination and method, A-57, A-61, A-66, A-80-81, and to provide a scientist, A-78, who could explain the product in sufficient detail to satisfy the other inventors. By placing Stewart Smith in contact with Dr. Linden at Colorado State University, A-78, Mr. Loken provided someone with expertise in the chitinous products, to the other inventors. By providing evidence to the named inventors that Mr. Loken's process and method worked previously with Gustafson's product, A-78-79, Mr. Loken provided verification of his protocol that Novozymes otherwise would not have. The contact between Stewart Smith and Dr. Linden and between Novozymes and Gustafson are the first pieces of corroborating evidence similar to the *Ethicon* list. Second, Mr. Loken and Loken-Flack had been involved in independent testing of the combination of its product with other products as well as the method for

combining them. A-54, A-82-97. His background in combining the concentrated chitinous product, unknown to the named inventors, was a significant contribution and the fact of his independent testing prior to the named inventor's alleged idea to combine their LCO with a chitinous product is corroborating evidence.

The trial court held that in March 2004 Novozymes and Loken-Flack entered into a non-disclosure agreement, *order*, page 4 A-5, and that "in ensuring [sic] months, Mr. Loken discussed with Novozymes [sic] representatives various concentrations of ODC to try." *Id*. This piece of corroborating evidence shows that Novozymes and Loken-Flack did in fact work together to develop, to refine and to test the combination and Mr. Loken's method, mirroring the third item in *Ethicon's* list of corroborating evidence. This same agreement exceeds the fourth corroborating item in the *Ethicon* list that is, it is a *formal* business relationship that developed between Novozymes and Loken-Flack and consequently Mr. Loken. During the lengthy period of time, over 2 years, that Mr. Loken worked with Novozymes, he introduced a variety of concentrations of the chitinous product. A-58. The evidence corroborating this is in the patent-in-suit itself, showing that over the period of time a variety of concentrations were tried. A-44-46. Mr. Loken worked with Novozymes from, at least, March of 2004, *id*. through 2006 or 2007. A-53. Consequently, this work of at least two years is corroborating evidence similar to that found by the *Ethicon* court. Similar to the sixth piece of corroborating evidence

in the *Ethicon* opinion, Mr. Loken and Loken-Flack never received any pay for their work.

The results of the tests that Loken-Flack and Novozymes embarked upon in this period of time are reported in detail in the patent. A41-51. In *Ethicon* the court found corroborating evidence in the similarity between sketches and patent figures, *Ethicon* 135 F.3d at 1464. In this case there is no similarity, but identity of test results.

Finally, in *Ethicon* the court considered the corroborating evidence of the letter between the person asking to be added as an inventor, stating that he could no longer be a member of that named inventor's business.

In this case, there are two particularly telling emails. In the email of April 7, 2004, A-78, Mr. Loken communicates with named inventor, Stewart Smith, concerning the patents listed as prior art in the ODC patent. He provided Dr. Linden's contact information so that Mr. Smith could acquire more information about ODC. Moreover, he reported to Mr. Smith that their conversation had included a discussion about applying for a joint patent. A-78. Mr. Smith did not respond by stating that they were not interested in a joint patent, nor did he contradict Mr. Loken's recollection, but rather thanked Mr. Loken for Dr. Linden's contact information and mentioned that the field trials with Loken-Flack's compound using Mr. Loken's method would begin in the Spring. *Id*. It is axiomatic that the failure to

contest a statement is evidence of the veracity of the statement. *See,* Fed. R. Ev. 801(d)(2)(B) *and see In re Columbia Sec. Lit.*, 155 F.R.D. 466, 478 (S.D.N.Y. 1994) (holding that a defendant who knew of statements and took no action to deny or to correct them may be considered to have admitted the statements through adoption). In this case, the Court knows that Mr. Smith knew of the statements concerning the discussion of a joint application for a patent on a combination of BEYOND™ and Novozymes' product[9], and failed to deny or to correct the statements. Viewing the evidence in the light most favorable to the non-movants, Mr. Loken and Loken-Flack, the Court should hold that one of the co-inventors admitted the truth of the statements.

Mr. Loken specifically said "we agreed this approach (a joint patent) has merit and deserves further discussion." A-78. Mr. Smith did not deny this statement. Moreover the corroborating evidence from Mr. Flack in his email of March 2004, A-79, while not sufficient alone, in combination with all of these other facts, documents, and circumstances shows enough corroborating evidence to get beyond a summary judgment. In this email, Mr. Flack reports that he spoke with John Hren

[9] In its briefing in the trial court, Novozymes claims this email should be disregarded because Mr. Loken, perhaps inartfully, did not say "joint patent and ODC and LCO." Taking the evidence in the light most favorable to Mr. Loken, the trial court should have found in his replay *at the time,* Mr. Smith should have raised that. Moreover, the products being tested that could be the subject of a patent were only the ODC and LCO in combination.

at Novozymes concerning the testing evidence that Loken-Flack had in combining its product with a "rhizo." A-79. This could only refer to Mr. Loken's previously developed protocol. In notes about a subsequent telephone call he states that he had to start over with "Stu Smith," A-79, who finally agreed to start a test of combining the two products using Mr. Loken's previously developed protocol and Smith suggested OPTIMIZE® "as the leading candidate for a rhizo." A-79. This corroborates Mr. Loken's testimony that he invented the combination of the two products, the method of combining his product with theirs and disclosed this to Novozymes. These documents, while individually do not provide corroboration, in combination certainly provide as much corroboration as the *Ethicon* case found was sufficient. Mr. Loken is an inventor and submitted sufficient cumulative corroboration of his inventorship to survive summary judgment.

3. **The Trial Court Erred in Granting Summary Judgment to Defendant Because it Failed to Take the Facts in the Light Most Favorable to the Non-Moving Parties and Make All Inferences in Favor of the Non-Moving Parties, Mr. Loken and Loken-Flack.**

"Summary judgment is appropriate when there is no genuine issue of material fact and the non-moving parties entitled to judgment is a matter of law . . . 'thus, summary judgment may be granted when no "reasonable jury could return a verdict for the non-moving party."'" *Fina*, 123 F.3d at 1472 (citations omitted). All facts

must be taken in the light most favorable to the non-moving party and all reasonable inferences drawn in favor of the non-moving party. In this case, if anything, the trial court took the evidence in the light most favorable to the movants and made inferences in the movants' favor. For instance, at one point, the court stated that one piece of plaintiffs' corroborating evidence "does not refute the *possibility* that Drs. Smith and Osborne independently conceived of a potential synergistic effect between LCO and ODC." A-12. Given all of the corroborating evidence supplied by Mr. Loken and Loken-Flack, and all of the direct evidence from Mr. Loken's testimony, the possibility that the named inventors conceived of the potential combination, is irrelevant as a consideration. They knew no way of making this combination work. A-57.

In taking the evidence on the record in the light most favorable to Mr. Loken and Loken-Flack, it is clear that a fact-finder could determine that they have proved by clear and convincing evidence that they indeed used the information that they had gathered from their independent tests with Gustafson and Scott, A-82-97, and the method and protocol Mr. Loken invented, to invent the combination of two products BEYOND™ and OPTIMIZE® for a synergistic effect. As this court held in *Fina*, there is no explicit lower limit on the quantity or quality of inventive contribution, so long as it is a substantial contribution. *See Fina,*123 F.3d at 1473. Moreover, the list of corroborating evidence that was sufficient in *Ethicon*, when considered in the

light most favorable to Mr. Loken and Loken-Flack, shows that they had sufficient corroborating evidence, while not all of one piece, to survive summary judgment.

This court should remand the case to the trial court for a trial allowing Mr. Loken and Loken-Flack to present its evidence so it can show by clear and convincing evidence that Mr. Loken is an inventor.

CONCLUSION

This court should remand the case to the trial court for a trial allowing Mr. Loken and Loken-Flack to present its evidence so it can show by clear and convincing evidence that Mr. Loken is an inventor of the '631 Patent.

DATED THIS 8th day of December 2014.

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ADDENDUM
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IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLORADO

Civil Action No. 13-cv-01617-MSK-BNB

LOKEN-FLACK, LLC, and
LYNN LOKEN,

Plaintiffs,

v.

NOVOZYMES BIOAG, INC.,

Defendant.

FINAL JUDGMENT

In accordance with the orders filed during the pendency of this case, and pursuant to Fed. R. Civ. P. 58(a), the following Final Judgment is hereby entered.

Pursuant to the Opinion and Order Granting Novozymes' Motion for Summary Judgment of Chief Judge Marcia S. Krieger entered on September 30, 2014 it is

ORDERED that judgment is entered in favor of Novozymes and against the Plaintiffs on the sole claim in this action.

Dated at Denver, Colorado this 1st day of October, 2014.

FOR THE COURT:
JEFFREY P. COLWELL, CLERK

By: s/ D. Kalsow
Deputy Clerk

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLORADO
Chief Judge Marcia S. Krieger

Civil Action No. 13-cv-01617-MSK-BNB

LOKEN-FLACK, LLC, and
LYNN LOKEN,

Plaintiffs,

v.

NOVOZYMES BIOAG, INC.,
Defendant.

OPINION AND ORDER GRANTING NOVOZYMES' MOTION FOR SUMMARY JUDGMENT

THIS MATTER comes before the Court pursuant to cross-motions for summary judgment by the Plaintiffs **(# 35)**, and the Defendant **(# 38, 40)**. Each side filed responses **(# 42, 43)** and replies **(# 47, 48)** to those motions. Also pending are unopposed motions by both parties to restrict access **(# 34, 37, 53)** to certain filings and supporting exhibits.[1]

[1] After being advised that a parallel proceeding was pending between these parties before the U.S. Patent and Trademark Office ("USPTO"), raising precisely the same issues, this Court issued an Order to Show Cause **(# 50)** inquiring why this Court should not stay this action pending resolution of the matter by the USPTO. The Plaintiffs responded **(# 52)** that they had no objection to the Court issuing such a stay, but the Defendant opposed **(# 55, 56)** a stay, arguing (among other things) that deferring to the USPTO's resolution would unnecessarily delay conclusion of the dispute, and that the USPTO was proposing to apply a less stringent standard of review than that compelled by Federal Circuit precedent. Thereafter, the Plaintiffs moved to strike **(# 57)** the Defendant's response as a prohibited sur-reply in support of its summary judgment motion, and the Defendant responded **(# 58)** to the Plaintiffs' motion.

In issuing the Order to Show Cause, the Court was merely attempting to ascertain whether there was a reason for the Court to continue to maintain what, by all appearances, is a proceeding entirely duplicative of the USPTO action; it had no intention of inviting additional briefing or inducing any expansion of the litigation. For the reasons set forth herein, the Court addresses the relation of this action to the pending USPTO proceeding. Because the Court has not considered the parties' responses to the Order to Show Cause for any other purpose, the Motion to Strike is denied as moot.

FACTS

Defendant Novozymes Bioag, Inc. ("Novozymes") is the holder of U.S. Patent Number 8,357,631 ("the '631 patent"). The patent is issued in the names of Inventors Raymond Smith and Robert Osburn, based on a patent application they submitted in January 2007. The patent covers "compositions and methods for enhancing plant growth and crop yield in legumes and non-legumes."

For purposes of this matter, only a highly summarized explanation of the patented method is warranted. It is an effort to accelerate the process of "nitrogen fixation" in plants. Nitrogen fixation results when a plant releases chemicals called "flavinoids," that cause soil bacteria, known as "rhizobia" to release "nod factor" compounds. The nod factors cause the plant to form root nodules, the rhizobia take up residence in those nodules, and begin converting atmospheric nitrogen into a form that is more usable by the plants. Past efforts to enhance the nitrogen fixation process involved applying nod factors themselves or rhizobia to seeds or soil at the time of planting, rather than waiting form them to develop naturally.

The patented method focuses on a specific type of nod factor, known as "lipo-chitooligosaccharides" or, more conveniently, "LCOs." The '631 patent covers several methods in which LCOs are combined with various other compounds, including flavinoids, herbicides, or, as particularly relevant here, compounds known as "chitins" or "chitosans." Chitins are essential components of fungi and insects that harm plants, and plants exposed to chitosans produce chitin-degrading enzymes, thus protecting the plant. Thus, for example, Claim 1 of the '631 patent addresses "a composition for enhancing plant growth . . . comprising at least one [LCO] and one or more . . . chitins [or] chitosans."

The Plaintiffs here assert a single claim for "correction of inventorship" on the '631 patent, pursuant to 35 U.S.C. § 256. They contend that the listing of inventors should be modified to include Plaintiff Lynn Loken as a co-inventor, alongside Drs. Smith and Osburn. Because this claim turns on the circumstances of the invention of the patented method, the Court turns to the (limited) evidence in the record on that point.

Plaintiff Loken-Flack, LLC ("L-F") was the "marketing arm" of an entity[2] that sold an "organically derived colloids" (or "ODC") product consisting of chitinous compounds under the name "Beyond." Prior to L-F's development of Beyond and other ODC products, the use of chitin in agricultural applications was economically impractical; L-F made practical use of ODCs possible. The record reflects that in between 2001 and 2003, L-F was in contact with various manufacturers of products promoting plant growth, proposing to combine Beyond with the products made by those entities. However, it is apparently undisputed that none of those manufacturers' products were LCOs.

According to the Plaintiffs, Mr. Loken, one of L-F's principals, had conceived of the idea of combining Novozymes'[3] LCO product, known as "Optimize," with an ODC product as early as 2001 or 2002, after he had achieved some success from his combinings of ODC with other manufacturer's plant growth products. After learning of the particular chemical structure of Optimize (apparently in or about 2003), Mr. Loken decided to approach Novozymes to propose combining ODC with Novozymes' products. He contends that Novozymes was not previously aware of L-F's development of Beyond or the availability of an economically-practical chitin

[2] For practical purposes, the Court will treat L-F as both the manufacturer and marketer of the ODC products.

[3] At the time, Novozymes was known as "Nitragin, Inc." For purposes of clarity, the Court will refer to it at all times by the name "Novozymes," including substituting that name of "Nitragin" when quoting from exhibits.

product. He contends that he introduced Novozymes to the concept of combining and LCO product with an ODC product in or about March 2004, the date that Novozymes and L-F entered into a non-disclosure agreement. In ensuring months, Mr. Loken discussed with Novozymes representatives various concentrations of ODC to try.

Novozymes contends that Drs. Smith and Osburn conceived of the method described in the patent in October 2003 while working for Novozymes. Relying on the mostly on the Plaintiffs bearing the burden of proof, Novozymes has not offered a substantial discussion of the circumstances surrounding Drs. Smith and Osburn's invention of the method. Rather, it merely points out that in or about March 2004, when L-F contacted Novozymes to discuss its ODC product, Dr. Smith considered the possibility that Beyond could be a means by which he could reduce the LCO-chitin method he had already conceived of to practice, and that Novozymes therefore entered into a nondisclosure and materials supply agreement with L-F to begin tests. Novozymes disputes Mr. Loken's statement that he first conceived of a LCO-chitin combination in 2001 or 2002, as Novozymes' commercial LCO product, Optimize, was not released until January 2004. (Mr. Loken responds by positing that he may have been aware of the product during its field testing phases.) Novozymes points to Mr. Loken's deposition, in which he testified that he was not aware of Optimize's chemical composition, or even what an LCO was, until approximately 2005. Rather, Novozymes contends that Mr. Loken was simply a "salesman" for L-F, informing Novozymes of the availability, nature, and characteristics of its ODC product, but not contributing to the conception of a patentable LCO-chitin method.

ANALYSIS

A. Standard of review

The parties present the instant matter by means of cross-motions for summary judgment. Rule 56 of the Federal Rules of Civil Procedure facilitates the entry of a judgment only if no trial is necessary. *See White v. York Intern. Corp.*, 45 F.3d 357, 360 (10th Cir. 1995). Summary adjudication is authorized when there is no genuine dispute as to any material fact and a party is entitled to judgment as a matter of law. Fed. R. Civ. P. 56(a). Substantive law governs what facts are material and what issues must be determined. It also specifies the elements that must be proved for a given claim or defense, sets the standard of proof and identifies the party with the burden of proof. *See Anderson v. Liberty Lobby, Inc.*, 477 U.S. 242, 248 (1986); *Kaiser-Francis Oil Co. v. Producer's Gas Co.*, 870 F.2d 563, 565 (10th Cir. 1989). A factual dispute is "genuine" and summary judgment is precluded if the evidence presented in support of and opposition to the motion is so contradictory that, if presented at trial, a judgment could enter for either party. *See Anderson*, 477 U.S. at 248. When considering a summary judgment motion, a court views all evidence in the light most favorable to the non-moving party, thereby favoring the right to a trial. *See Garrett v. Hewlett Packard Co.*, 305 F.3d 1210, 1213 (10th Cir. 2002).

If the movant has the burden of proof on a claim or defense, the movant must establish every element of its claim or defense by sufficient, competent evidence. *See* Fed. R. Civ. P. 56(c)(1)(A). Once the moving party has met its burden, to avoid summary judgment the responding party must present sufficient, competent, contradictory evidence to establish a genuine factual dispute. *See Bacchus Indus., Inc. v. Arvin Indus., Inc.*, 939 F.2d 887, 891 (10th Cir. 1991); *Perry v. Woodward*, 199 F.3d 1126, 1131 (10th Cir. 1999). If there is a genuine dispute as to a material fact, a trial is required. If there is no genuine dispute as to any material

fact, no trial is required. The court then applies the law to the undisputed facts and enters judgment.

If the moving party does not have the burden of proof at trial, it must point to an absence of sufficient evidence to establish the claim or defense that the non-movant is obligated to prove. If the respondent comes forward with sufficient competent evidence to establish a *prima facie* claim or defense, a trial is required. If the respondent fails to produce sufficient competent evidence to establish its claim or defense, then the movant is entitled to judgment as a matter of law. *See Celotex Corp. v. Catrett*, 477 U.S. 317, 322-23 (1986).

This case involves cross-motions for summary judgment. "Because the determination of whether there is a genuine dispute as to a material factual issue turns upon who has the burden of proof, the standard of proof and whether adequate evidence has been submitted to support a *prima facie* case or to establish a genuine dispute as to material fact, cross motions must be evaluated independently." *In re Ribozyme Pharmaceuticals, Inc., Securities Litig.*, 209 F. Supp. 2d 1106, 1112 (D. Colo. 2002); *see also Atlantic Richfield Co. v. Farm Credit Bank of Wichita*, 226 F.3d 1138, 1148 (10th Cir. 2000); *Buell Cabinet Co. v. Sudduth*, 608 F.2d 431, 433 (10th Cir. 1979) ("Cross-motions for summary judgment are to be treated separately; the denial of one does not require the grant of another").

B. Governing law

35 U.S.C. § 256 provides that "whenever through error . . . an inventor is not named in an issued patent, the Director [of the USPTO] may . . . with proof of the facts and such other requirements as may be imposed, issue a certificate correcting the error." Notwithstanding the statute's reference to "the Director," the statute provides a private right of action to challenge

inventorship, and that right may be vindicated in the federal district court.[4] *MCV, Inc. v. King-Seeley Thermos Co.*, 80 F.2d 1568, 1570 (Fed. Cir. 1989).

Issuance of a patent creates a rebuttable presumption that the named inventors are the true and only inventors. *Caterpillar, Inc. v. Sturman Industries, Inc.*, 387 F.3d 1358, 1377 (Fed. Cir. 2004). To overcome this presumption, the party seeking correction bears the burden of showing that he was a co-inventor. *Id.* To be a joint inventor, the party seeking correction must show that he "ma[d]e a contribution to the conception of the claimed invention that is not insignificant in quality, when that contribution is measured against the dimension of the full invention." *Id.* "Conception" of an invention means "a definite and permanent idea of the complete and operative invention, as it is hereafter to be applied in practice," such that only "ordinary skill would be necessary to reduce the invention to practice, without extensive research or experimentation." *Ethicon, Inc. v. U.S. Surgical Corp.*, 135 F.3d 1456, 1460 (Fed. Cir. 1998). It is not enough for the party to show that he explained to the named inventors "concepts that are well known in the current state of the art." *Caterpillar*, 387 F.3d at 1377. The conception analysis necessarily turns on "the inventor's ability to describe his invention with particularity." *Borroughs Wellcome Co. v. Barr Laboratories, Inc.*, 40 F.3d 1223, 1228 (Fed. Cir. 1994).

The party seeking correction's burden is higher than normal: he must show his co-inventor status by clear and convincing evidence. *Caterpillar*, 387 F.3d at 1377. Moreover, he may not rely on his own testimony alone; he is required to supply sufficient corroborating evidence. *Id.* Corroborating evidence may take a variety of forms, such as contemporaneously-produced documents prepared by the putative inventor, circumstantial evidence about the

[4] *MCV* suggests that resort to judicial determination comes only after the parties have first presented their dispute to the Director of the USPTO and failed to attain "consensus." 870 F.2d at 1570. This Court will assume, without necessarily finding, that the parties' dispute over whether this action should be stayed pending USPTO consideration is indicative of a failure to reach consensus before the USPTO over the appropriate resolution.

inventive process, and oral testimony of someone other than the alleged inventor. *Ethicon*, 135 F.3d at 1461. The sufficiency of corroborating evidence is subject to a "rule of reason," in which the Court must consider the evidence in context, mindful of all of the facts and circumstances and surrounding evidence, and upon the making of any appropriate credibility determinations. *Ethicon*, *id.* at 1464 (affirming court's finding of sufficient corroboration made "after an extensive hearing") To the extent underlying factual issues can be appropriately resolved, the determination of inventorship presents a question of law. *Checkpoint Systems, Inc. v. All_Tag Sec., S.A.*, 412 F.3d 1331, 1338 (Fed. Cir. 2005).

C. Merits

As noted above, the Court must consider cross-motions for summary judgment independently. Because the Court ultimately finds in favor of Novozymes here, it need only turn to that motion.

The touchstone of the inquiry is "conception" of the invention. Here, the "invention" is the notion of combining an LCO product with a chitin product to obtain a synergistic effect. The Court has some doubt that the Plaintiffs have shown that Mr. Loken actually conceived of the invention prior to his contacts with Novozymes, as, by definition, one cannot conceive of an invention of this type without first knowing what an LCO is. Asked whether he "kn[e]w what an LCO was" at the time he first learned about Novozyme's LCO product, Optimize, Mr. Loken answered "no." He was then asked "when did you learn what an LCO was? When did you first hear of LCOs?," and he responded "when I started investigating and working with [Novozymes]."

This evidence is not consistent with the narrative posited by the Plaintiffs: that Mr. Loken initiated contact with Novozymes to suggest a specific idea for an LCO/ODC combination. Mr.

Loken could not have been drawn to Novozymes' Optimize product because it was an LCO, thus fitting his idea of an LCO/ODC combination, as he did not even know at that time what an LCO was. Rather, the record instead suggests something more prosaic: Mr. Loken conceived of the idea of combining Optimize with ODC, not because Optimize was an LCO (and not because Mr. Loken conceived of a potential synergistic biochemical relationship between LCOs and chitins), but merely because Optimize was a prominent plant growth product. Mr. Loken had previously proposed combining L-F's ODC product with other plant growth products, such as Scott's Miracle-Gro product, Gustafson's Bio-Yield product, and Gustafson's Kodiak product. Thus, his proposal to also combine ODC with Optimize was simply because Optimize was another potentially complementary product, and not because of the unique chemical composition of Optimize or the peculiars of a perceived synergy between LCOs and chitins.

But ultimately, the Court need not make such a broad finding because this matter is more easily resolved on a lack of adequate corroboration of the Plaintiff's key assertion: that Mr. Loken proposed combining LCOs and chitins in discussions with Novozymes in or about 2003.

The Plaintiffs' corroborating materials from the relevant time period consist primarily of listings of plant growth product manufacturers, including Novozymes, that L-F sought to contact. These records merely corroborate the undisputed fact that L-F had some communications with Novozymes during the 2003-2004 time period, but they do not memorialize the contents of those communications. Some evidence of the content of the communications is necessary, as Novozymes concedes that it had discussions with L-F- during this time period, but that those discussions merely consisted of L-F alerting Novozymes to the fact that L-F was selling a commercially-available chitin preparation. Without some evidence that the conversation in of

those calls included Mr. Loken[5] proposing an LCO/ODC combination to Novozymes, the Plaintiffs lack the necessary corroboration.

The first corroborating evidence of an actual conversation between L-F (through Mr. Flack) and Dr. Smith is an memo from Mr. Flack to Mr. Loken, arguably dated March 19, 2004. That note recites a "2d phone call from John [Hren, a Novozymes representative]" in which Mr. Hren stated that he had received a sample of ODC that L-F had sent, but Mr. Hren stated that he lacked the authority to "start a test" and "had to consult with others." Apparently, Mr. Hren had Mr. Flack call Dr. Smith (causing Mr. Flack to lament in his notes that "I started over!!"). Mr. Flack indicates that he spoke to Dr. Smith and that "Dr. Smith finally agreed to start a test. He suggested Optimize as the leading candidate for a Rhizo."[6]

Even when taken in the light most favorable to the Plaintiffs, this evidence is insufficient to corroborate the Plaintiffs' contention that Mr. Loken (arguably, through Mr. Flack) first suggested the notion of an LCO/ODC combination to Dr. Smith; it merely establishes that Mr. Flack and Dr. Smith had discussions about conducting a test that would involve Optimize (and presumably, L-F's ODC). The fact that the parties agreed to conduct such a test does not shed any light on the question of who first conceived of the idea of pairing and LCO and an ODC, much less how that notion was communicated. It does not, for example, refute Novozymes'

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[5] The Plaintiffs' position is further weakened by the fact that most of the communications between L-F and Novozymes were conducted by Mr. Flack, not Mr. Loken. Indeed, the Plaintiffs' summary judgment motion does not identify a single instance of Mr. Loken speaking directly to Drs. Smith or Osburn. Yet the Plaintiffs have not offered any testimony from Mr. Flack himself about the contents of his communication with Novozymes.

[6] Novozymes has provided the affidavit of Dr. Smith, who gives his version of that call with Mr. Flack, which Dr. Smith places at in or about March 2004. Dr. Smith states that Mr. Flack inquired about whether Novozymes "would be interested in testing a combination of a 'Rhizo' and ODC and, if so, whether I could recommend a specific 'Rhizo.'" Dr. Smith states that he declined to make such a suggestion, knowing that a rhizobia/ODC combiation "would not work as well as the LCO (Optimize)/ODC combination that Dr. Osburn and I had previously invented," and that he "then disclosed" the LCO/ODC combination to Mr. Flack "pursuant to a Mutual Confidential Disclosure Agreement."

contention that Dr. Smith conceived of the LCO-chitin combination in 2003 but did not endeavor to actually test it until he was contacted by L-F and informed of the availability of L-F's commercial ODC preparation in 2004.

The Plaintiffs also point to a July 26, 2006 e-mail from Mr. Hren to an individual named Kyle Rushing, with the subject line reading "ODC (Chitosan): LCO Application Rate Ratio." The e-mail is in response to an unknown query, making its context somewhat opaque, but Mr. Hren states that Novozymes "has not performed any scientific step ladder rate research," and although he states that "we see combined benefits," he acknowledges that "I can't provide any better guidance than that." Near the end of the e-mail, Mr. Hren states "Up to present, we really threw in ODC more as a curiosity screen than a serious player."

The Plaintiffs seize on this statement as corroborating their contention that Novozymes began testing an LCO/ODC combination at the urging of Mr. Loken, rather than out of Dr. Smith's own conception of a potential benefit from the combination. But, once again, the e-mail does not sustain the weight that the Plaintiffs impose on it. It merely indicates that Novozymes did not initially expect the combination to show significant results, but it does not address the essential question of who conceived the idea of combining the two substances and when. It does not refute the possibility that Drs. Smith and Osburn independently conceived of a potential synergistic effect between LCO and ODC, but considered that testing in general (or, perhaps, the specific type of testing that Novozymes ultimately attempted, due to insufficient methodology or concerns about the characteristics of the test's components) might fail to demonstrate such an effect.

Simply put, the Court finds that none of the corroborating evidence supplied by the Plaintiffs is sufficient to carry their burden of showing, by clear and convincing evidence, that

Mr. Loken was the first to conceive of the idea of combining and LCO and a chitin, and that he conveyed that idea to Drs. Smith and Osburn (or even that the three men formulated the idea together, collectively). Certainly, the evidence corroborates the fact that L-F made contact with Novozymes and that the parties entered into a relationship by which Novozymes began testing a combination of Optimize and L-F's ODC, but the circumstances Mr. Loken's alleged initial conception of the idea and his first communication of it to Novozymes remains uncorroborated by any meaningful evidence beyond his own testimony. Consequently, the Court finds that the Plaintiffs have failed to come forward with evidence that, even taken in the light most favorable to them, would be sufficient to carry their burden under the heavy "clear and convincing" standard.[7] Accordingly, Novozymes' motion for summary judgment is granted.

D. Motions to Restrict Access

Both sides have filed motions seeking to restrict public access to certain filings and supporting exhibits under D.C. Colo. L. Civ. R. 7.2. The Plaintiffs' motion **(# 34)** seeks to restrict nearly all of the Plaintiffs' exhibits in support of their summary judgment motion (exhibits reflecting L-F's proposals to other plant growth product manufacturers and Mr. Flack's list of contacts, among other things), stating only the bare conclusion that "the documents to be restricted discuss confidential information, some of which has been designated as highly confidential, attorneys' eyes only" and that "the material concerns products and experiments that

[7] This poses an interesting procedural question. Among the reasons that Novozymes gave for opposing a stay of proceedings in this matter pending the USPTO's determination was a belief that the USPTO would hold the Plaintiffs to a lower "preponderance of the evidence" standard. If that is indeed the case, this Court's finding, which the Court expressly makes clear is dictated by the considerable burden posed on the Plaintiffs by the more exacting "clear and convincing evidence" standard, should be afforded no preclusive and little persuasive effect by the UPSTO. It may be possible – although this Court makes no findings in this regard – for the USPTO to conclude that the Plaintiffs' corroborating evidence is sufficient to meet a "preponderance of the evidence" standard, even if, as this Court finds, it is not compelling enough to rise to the more exacting "clear and convincing" standard. Thus, this Court's resolution of this case may have no effect on the ongoing USPTO proceeding.

if disclosed to competitors of either the Plaintiffs or Defendant could be used to their detriment." The motion does not specify the sensitive information with any particularity, nor does it address the possibility of alternative measures short of restricting access.

Novozymes filed two motions **(# 37, 53)** seek to restrict access. The first seeks to restrict access to the entirety of its summary judgment motion and two exhibits in support (the full 41-page response by Novozymes to Plaintiffs' discovery requests and excerpts from Mr. Loken's deposition), arguing that the former "contains Highly confidential business information of a non-party to this case and one of [L-F's] direct competitors" and that the latter "contains information designated by Plaintiffs." (No further explanation of the particular information at issue is offered.) The second motion seeks to restrict access to the entirety of Novozymes' response to the Court's Order to Show Cause and an accompanying exhibit, again consisting of portions of Mr. Loken's deposition testimony. Novozymes states that the response and deposition excerpt "contain information designated *by Plaintiffs* as Confidential and/or Highly Confidential – Outside Counsel Eyes Only under the Protective Order" and that no alternative to restricted access is possible "because redaction would deprive the Court of the cited information." Once again, the motion does not identify the sensitive material in question with any particularity.

The Supreme Court acknowledged a common law right of access to judicial records in *Nixon v. Warner Communications, Inc.*, 435 U.S. 589, 597 (1978). This right is premised upon the recognition that public monitoring of the courts fosters important values such as respect for the legal system. *See In re Providence Journal Co.*, 293 F.3d 1, 9 (1st Cir. 2002). Judges have a responsibility to avoid secrecy in court proceedings because "secret court proceedings are anathema to a free society." *M.M. v. Zavaras*, 939 F. Supp. 799, 801 (D. Colo. 1996). There is a presumption that documents essential to the judicial process are to be available to the public, but

they may be sealed when the public's right of access is outweighed by interests which favor nondisclosure. *See United States v. McVeigh*, 119 F.3d 806, 811 (10th Cir. 1997). Such a showing is required to ensure public confidence in the judicial process. It is critical that the public be able to review the factual basis of this Court's decisions and evaluate the Court's rationale so that it may be confident that the Court is functioning as a neutral arbiter. *Id.* at 814.

D.C. Colo. L. Civ. R. 7.2(B) imposes specific showings that a party seeking to restrict public access to a filed document must make: (i) a showing that "the interest to be protected . . . outweighs the presumption of public access"; (ii) identification of "a clearly defined and serious injury that would result if access is not restricted"; and (iii) an explanation why "no alternative to restricted access [such as redaction or summarization, among other things] will adequately protect the interest in question." In addition, the rule makes clear that "stipulates between the parties and stipulated protective orders with regard to discover, alone, are insufficient to justify restricted access." D.C. Colo. L. Civ. P. 7.2(B)(2).

Neither party's motions comport with this standard. The parties have addressed the privacy interests they invoke in only the most abstract and general terms, have offered no analysis of the public interest in access to the documents in question or sought to balance those two interests, have not identified anything more than highly conclusory and speculative injuries that might arise if access is not restricted, and have not meaningfully addressed the availability of alternatives to restricted access. For example, Novozymes' summary judgment motion cites to Exhibit C, its 41-page response to the Plaintiffs' discovery requests, three times in its summary judgment motion, with those citations referencing only four pages of the 41-page document. There is no reason why Novozymes could not have simply provided the four relevant pages and/or redacted the remaining 37, arguably ameliorating the need to restrict access.

In any event, having reviewed all of the relevant documents, this Court finds that none of the material for which restricted access is sought presents obvious risks of clearly-defined and serious injuries that will result if public access to the entirety of the record is permitted. For example, the "highly confidential business information" cited by Novozymes' motion as being found in its 41-page discovery response consists of three substantive paragraphs stating facts that are either set forth in pertinent detail in the '631 patent itself or recited in substantial part herein, with little apparent risk of harm to Novozymes or the unidentified "non-party to this case." Similarly, the fact that L-F made proposals to other plant growth product manufacturers more than a decade ago, as shown in some of the exhibits at issue here, seems unlikely to pose any particular risk of substantial harm to L-F if disclosed now. Accordingly, the Court finds that none of the parties' Motions to Restrict Access have merit, and the Court directs that all documents filed under restricted access in this matter be unrestricted.

CONCLUSION

For the foregoing reasons, Novozymes' Motion for Summary Judgment **(# 38, 40)** is **GRANTED**. The Clerk of the Court shall enter judgment in favor of Novozymes and against the Plaintiffs on the sole claim in this action. The Plaintiffs' Motion for Summary Judgment **(# 35)** is **DENIED AS MOOT**. The parties' Motions to Restrict Access **(# 34, 37, 53)** are **DENIED** and the Clerk of the Court shall lift all access restrictions on Docket # 36, 38, and 54. The Plaintiffs' Motion to Strike **(# 57)** is **DENIED**.

Dated this 30th day of September, 2014.

BY THE COURT:

Marcia S. Krieger
Chief United States District Judge

EXHIBIT A

US008357631B2

(12) **United States Patent**
Smith et al.

(10) **Patent No.: US 8,357,631 B2**
(45) **Date of Patent: Jan. 22, 2013**

(54) **LIPO-CHITOOLIGOSACCHARIDE COMBINATION COMPOSITIONS FOR ENHANCED PLANT GROWTH AND YIELD**

(75) Inventors: **Raymond Stewart Smith**, Pewaukee, WI (US); **Robert Martin Osburn**, Mequon, WI (US)

(73) Assignee: **Novozymes Bioag, Inc.**, Brookfield, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 553 days.

(21) Appl. No.: **12/521,375**

(22) PCT Filed: **Jan. 8, 2008**

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§ 371 (c)(1),
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PCT Pub. Date: **Jul. 17, 2008**

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(51) **Int. Cl.**

A01N 43/16	(2006.01)
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A01N 43/36	(2006.01)
A01N 57/12	(2006.01)

(52) **U.S. Cl.** **504/117**; 504/140; 504/138; 504/128

(58) **Field of Classification Search** ..... None
See application file for complete search history.

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(57) **ABSTRACT**

Compositions and methods for enhancing plant growth and crop yield in legumes and non-legumes are described. The compositions include lipo-chitooligosaccharides in combination with chitins/chitosans or in combination with flavonoid compounds or in combination with a herbicide. The method includes applying the compositions to seeds and/or plants either concomitantly or sequentially.

31 Claims, No Drawings

LIPO-CHITOOLIGOSACCHARIDE COMBINATION COMPOSITIONS FOR ENHANCED PLANT GROWTH AND YIELD

This is a U.S. National Phase application of application number PCT/US2008/000235, filed Jan. 8, 2008 (which is incorporated herein by reference in its entirety), which claims Priority benefit of U.S. Provisional Applications 60/879,436 (filed Jan. 9, 2007) and 60/980,287 (filed Oct. 16, 2007).

BACKGROUND OF THE INVENTION

Nitrogen fixation plays a vital role in agricultural production by making atmospheric nitrogen available in a form that can be used by plants. In plants of the Leguminoseae family, the symbiotic interaction between the plants and nitrogen-fixing bacteria of the Rhizobiaceae family ("rhizobia") enhances plant growth and crop yield. The symbiotic interaction is initiated when a plant releases flavonoid compounds that stimulate rhizobial bacteria in the soil to produce "Nod-factors." Nod-factors are signaling compounds that induce the early stages of nodulation in plant roots, which lead to the formation of root nodules containing the nitrogen-fixing rhizobial bacteria. Although this process occurs naturally over time in legumes, agricultural procedures have been developed to begin the process earlier. These procedures include providing nitrogen-fixing bacteria to seeds or soil and applying Nod factors directly to seeds or soil prior to or at planting.

Nod factors have recently been shown to also enhance the germination, growth and yield of legumes and non-legumes through processes other than nodulation (U.S. Pat. No. 6,979,664; Prithiviraj et al., *Planta* 216: 437-445, 2003). Although the effects of Nod factors on nodulation have been widely studied and reviewed, e.g., Ferguson and Mathesius, J. *Plant Growth Regulation* 22: 47-72, 2003, the mechanisms for Nod factor effects independent of nodulation are not well understood. Application of Nod factors to seeds of legumes and non-legumes stimulates germination, seedling emergence, plant growth and yield in crop and horticultural plant species, e.g., as described in U.S. Pat. Nos. 6,979,664 and 5,922,316. Nod factors have also been shown to enhance root development (Olah, et al., *The Plant Journal* 44:195-207, 2005). Foliar application of Nod factors has also been demonstrated to increase photosynthesis (U.S. Pat. No. 7,250,068), and fruiting and flowering (WO 04/093,542) in crop and horticultural plant species.

Nod factors are lipo-chitooligosaccharide compounds (LCO's). They consist of an oligomeric backbone of β-1,4-linked N-acetyl-D-glucosamine ("GlcNAc") residues with an N-linked fatty acyl chain at the nonreducing end. LCO's differ in the number of GlcNAc residues in the backbone, in the length and degree of saturation of the fatty acyl chain, and in the substitutions of reducing and nonreducing sugar residues. LCO structure is characteristic for each rhizobial species, and each strain may produce multiple LCO's with different structures. LCO's are the primary determinants of host specificity in legume symbiosis (Diaz, Spaink, and Kijne, *Mol. Plant-Microbe Interactions* 13: 268-276, 2000).

LCO synthesis can be stimulated by adding the appropriate flavonoid, for a given genus and species of *rhizobium* during growth of the bacteria. The flavonoid molecules bind to the *rhizobium* and turn on bacterial genes for the production of specific LCO's which are released into the fermentation medium. In nature, leguminous plants release the appropriate flavonoid, which binds to soil rhizobia, turning on genes for LCO production. These LCO's are released by bacteria into the soil, bind to the roots of leguminous plants, and initiate a cascade of plant gene expression that stimulates formation of nitrogen-fixing nodule structures on legume roots. Alternatively, modified and synthetic LCO molecules can be produced through genetic engineering or chemical synthesis. Synthetic LCO's of the same molecular structure interact with plants and stimulate nodulation in the same manner as naturally produced molecules.

Chitins and chitosans, which are major components of the cell walls of fungi and the exoskeletons of insects and crustaceans, are also composed of GlcNAc residues. These compositions have been applied to seeds, roots, or foliage of a broad spectrum of crop and horticultural plants. Chitin and chitosan compositions enhance protection against plant pathogens, in part, by stimulating plants to produce chitinases, enzymes that degrade chitin (Collinge, et al., *The Plant Journal* 3: 31-40, 1993).

Flavonoids are phenolic compounds having the general structure of two aromatic rings connected by a three carbon bridge. Flavonoids are produced by plants and have many functions, e.g., as beneficial signaling molecules, and as protection against insects, animals, fungi and bacteria. Classes of flavonoids include chalcones, anthocyanidins, coumarins, flavones, flavanols, flavonols, flavanones, and isoflavones. (Jain and Nainawatee, *J. Plant Biochem. & Biotechnol.* 11: 1-10, 2002; Shaw, et al., *Environmental Microbiol.* 11: 1867-1880, 2006.)

SUMMARY OF THE INVENTION

The invention includes methods and compositions for increasing plant growth and crop yield. An exemplary composition comprises at least one lipo-chitooligosaccharide and at least one chitinous compound. Another exemplary composition comprises at least one lipo-chitooligosaccharide and at least one flavonoid compound selected from the group consisting of flavones, flavanols, flavonols, flavanones, and isoflavones. A further exemplary composition comprises at least one lipo-chitooligosaccharide and at least one herbicide. An exemplary method comprises administering a composition according to the invention to a plant or seed in an effective amount for enhancing plant growth or crop yield. In another embodiment, the method comprises sequentially treating a plant or a seed with at least one lipo-chitooligosaccharide and at least one chitinous compound or at least one flavonoid compound selected from the group consisting of flavones, flavanols, flavonols, flavanones, and isoflavones.

DETAILED DESCRIPTION OF THE INVENTION

The invention provides compositions and methods for enhancing plant growth and crop yield, and arises from the results of experiments, reported herein, that reveal improved effects of lipo-chitooligosaccharide in combination with chitin/chitosan, flavonoid compounds, or herbicidal compounds on plant growth and crop yield when applied to seeds and/or foliage.

For the purposes of this invention, a "lipo-chitooligosaccharide" ("LCO") is a compound having the general LCO structure, i.e., an oligomeric backbone of B-1,4- linked N-acetyl-Dglucosamine residues with an N-linked fatty acyl chain at the non-reducing end, as described in U.S. Pat Nos. 5,549,718; 5,646,018; 5,175,149; and 5,321,011. This basic structure may contain modifications or substitutions found in naturally occurring LCO's, such as those described in *Spaink, Annual Review of Microbiology* 54: 257288, 2000; D'*Haeze and Holsters, Glycobiology* 12: 79R-105R, 2002. Also

encompassed by the invention are synthetic LCO compounds, such as those described in W02005/063784, and LCO's produced through genetic engineering. Precursor oligosaccharide molecules for the construction of LCOs may also be synthesized by genetically engineered organisms, e.g., as in Samain et al., *Carbohydrate Research* 302: 35-42, 1997.

LCO's used in embodiments of the invention may be recovered from Rhizobiaceae bacterial strains that produce LCO's, such as strains of *Azorhizobium, Bradyrhizobium* (including *B. japonicum*), *Mesorhizobium, Rhizobium* (including *R. leguminosarum*), *Sinorhizobium* (including *S. meliloti*), and bacterial strains genetically engineered to produce LCO's. These methods are known in the art and have been described, for example, in U.S. Pat. Nos. 5,549,718 and 5,646,018, which are incorporated herein by reference. Commercial products containing LCO's are available, such as OPTIMIZE® (EMD Crop BioScience).

LCO's may be utilized in various forms of purity and may be used alone or with rhizobia. Methods to provide only LCO's include simply removing the rhizobial cells from a mixture of LCOs and rhizobia, or continuing to isolate and purify the LCO molecules thru LCO solvent phase separation followed by HPLC chromatography as described by Lerouge, et. al (U.S. Pat. No. 5,549,718). Purification can be enhanced by repeated HPLC, and the purifed LCO molecules can be freeze-dried for long-term storage. This method is acceptable for the production of LCO's from all genera and species of the Rhizobiaceae.

Within the legume family, specific genera and species of *rhizobium* develop a symbiotic nitrogen-fixing relationship with a specific legume host. These plant host:rhizobia combinations are described in Hungria and Stacey, *Soil Biol. Biochem.* 29: 819-830, 1997, which also lists the effective flavonoid Nod gene inducers of the rhizobial species, and the specific LCO structures that are produced by the different rhizobial species. However, LCO specificity is only required to establish nodulation in legumes. It is not necessary to match LCO's and plant species to stimulate plant growth and/or crop yield when treating seeds or foliage of a legume or non-legume with LCO's.

Chitinous compounds include chitin, (IUPAC: N-[5-[[3-acetylamino-4,5-dihydroxy-6-(hydroxymethypoxan-2-yl] methoxymethyl]-2-[[5-acetylamino-4,6-dihydroxy-2-(hydroxymethyl)oxan-3-yl]methoxymethyl-4-hydroxy-6-(hydroxymethypoxan-3-ys]ethanamide), and chitosan, (IUPAC: 5-amino-6-[5-amino-6-[5-amino-4,6-dihydroxy-2-(hydroxymethyl)oxan-3-yl]oxy-4-hydroxy-2-(hydroxymethyl)oxan-3-yl]oxy-2(hydroxymethyl)oxane-3,4-diol). These compounds may be obtained commercially, e.g., from Sigma-Aldrich, or prepared from insects, crustacean shells, or fungal cell walls. Methods for the preparation of chitin and chitosan are known in the art, and have been described, for example, in U.S. Pat. No. 4,536,207 (preparation from crustacean shells), Pochanavanich and Suntornsuk, *Lett. Appl. Microbiol.* 35: 17-21, 2002 (preparation from fungal cell walls), and U.S. Pat. No. 5,965,545 (preparation from crab shells and hydrolysis of commercial chitosan). Deacetylated chitins and chitosans may be obtained that range from less than 35% to greater than 90% deacetylation, and cover a broad spectrum of molecular weights, e.g., low molecular weight chitosan oligomers of less than 15 kD and chitin oligomers of 0.5 to 2 kD; "practical grade" chitosan with a molecular weight of about 150 kD; and high molecular weight chitosan of up to 700 kD. Chitin and chitosan compositions formulated for plant and soil treatment are also commercially available. Commercial products include, for example, ELEXA®-4PDB (Plant Defense Boosters, Inc.) and BEYOND™ (Agrihouse, Inc.).

LCO's and chitins/chitosans are structurally related. Chitin and chitosan can stimulate the production of chitinases by plants, and it has been shown that plant chitinases may inactivate and degrade LCO's as well as chitinous compounds (Staehelin, et al., *P.N.A.S. USA* 91: 2196-2200, 1994; Ferguson and Mathesius, J. *Plant Growth Regulation* 22: 47-72, 2003). In addition, commercially available chitosan formulations often contain heavy metals that are toxic to rhizobial bacteria and so prevent the production of LCOs. For these reasons, the use of rhizobial bacteria in combination with chitins/chitosans was previously contraindicated. However, as shown in the examples below, it is now demonstrated that application of an LCO compound and chitin/chitosan, either sequentially or simultaneously, to a plant or seed induces beneficial responses in plant growth and yield. While the mechanism for this effect is not proven, one hypothesis is that the LCO compounds bind to specific receptors on the plant or seed and initiate these beneficial responses before LCO degradation by chitinases can occur. Furthermore, this novel treatment method obviates the effects of heavy metals on LCO production by rhizobial bacteria.

In one embodiment of the invention, the composition may be prepared by combining one or more flavonoid and one or more LCO in an agriculturally appropriate solvent. An "effective amount" of the composition is an amount that increases plant growth or crop yield when compared with the growth or crop yield of plants or seeds that have not been treated with the composition. For example, flavonoid concentration in the composition may range from 20-800 μM, preferably 100-500 μM. LCO concentration in the composition may range from 10^{-5} M to 10^{-14} M, preferably from 10^{-6} M to 10^{-10} M. The LCO component may consist of purified or partly purified LCO, or a mixture of the LCO and the rhizobia that produce the LCO. The agriculturally appropriate solvent is preferably an aqueous solvent, such as water.

Appropriate flavonoids include compounds from the classes of flavones, flavanols, flavonols, flavanones, and isoflavones. Such compounds may include, but are not limited to, genistein, daidzein, formononetin, naringenin, hesperetin, luteolin, and apigenin. Flavonoid compounds are commercially available, e.g., from Natland International Corp., Research Triangle Park, N.C.; MP Biomedicals, Irvine, Calif.; LC Laboratories, Woburn Mass. Flavonoid compounds may be isolated from plants or seeds, e.g., as described in U.S. Pat. Nos. 5,702,752; 5,990,291; 6,146,668. Flavonoid compounds may also be produced by genetically engineered organisms, such as yeast, as described in Ralston, et al., *Plant Physiology* 137: 1375-1388, 2005.

In one embodiment of the invention, the composition may be prepared by combining one or more flavonoid and one or more LCO in an agriculturally appropriate solvent. An "effective amount" of the composition is an amount that increases plant growth or crop yield when compared with the growth or crop yield of plants or seeds that have not been treated with the composition. For example, flavonoid concentration in the composition may range from 20-800 μm, preferably 100-500 μm. LCO concentration in the composition may range from 10^{-5} M to 10^{-14} M, preferably from 10^{-6} M to 10^{-10} M. The LCO component may consist of purified or partly purified LCO, or a mixture of the LCO and the rhizobia that produce the LCO. The agriculturally appropriate solvent is preferably an aqueous solvent, such as water.

Although it is efficient and convenient to combine and apply the flavonoid or chitin/chitosan and LCO components in a single mixture, in one embodiment of the invention the

flavonoid or chitin/chitosan component and the LCO component may be applied separately and sequentially in either order. Other additives that may be applied either simultaneously or sequentially include fertilizers (e.g., calcium, nitrogen, potassium, phosphorous), micronutrients (e.g., copper, aluminum, magnesium, manganese, and zinc ions), and pesticides (e.g., fungicides, insecticides, herbicides, and nematicides).

In one embodiment of the invention, a composition comprising at least one LCO and at least one herbicide is applied to the foliage of a plant to improve plant growth or crop yield. Suitable herbicides include, but are not limited to bentazon, acifluorfen, chlorimuron, lactofen, clomazone, fluazifop, glufosinate, glyphosate, sethoxydim, imazethapyr, imazamox, fomesafe, flumiclorac, imazaquin, and clethodim. Commercial products containing each of these compounds are readily available. Herbicide concentration in the composition will generally correspond to the labeled use rate for a particular herbicide. LCO concentration in the composition may range from 10^{-5} M to 10^{-14} M, preferably from 10^{-6} M to 10^{-10} M. The agriculturally appropriate solvent used in applying the composition is preferably an aqueous solvent, such as water. The composition is generally applied to the plant at any time appropriate for weed control, preferably post-emergence.

In one embodiment, the composition comprises at least one LCO with a glyphosate-based herbicide, and treatment comprises application of this composition to plants that have been genetically modified for resistance to glyphosate.

The term "plant" as used herein includes tubers, roots, stems, leaves, flowers, and fruits. The composition may be applied directly to seeds or plants or may be placed in soil in the vicinity of a seed or plant prior to or at the time of planting. In a preferred embodiment, the composition is sprayed on seeds, tubers, or foliage. Seedlings, as well as more mature plants, may be treated. Flowers and fruits may also be treated by spraying. Roots of transplants may be sprayed or dipped in the composition prior to planting.

An "effective amount" of the composition is an amount that increases plant growth or crop yield when compared with the growth or crop yield of plants or seeds that have not been treated with the composition.

The composition may be applied to monocot or dicot plants, and to legumes and non-legumes. In one embodiment, the composition is applied to field-grown plants. In another embodiment, the composition is applied to greenhouse-grown plants. For example, the composition may be applied to seeds or foliage of legumes, such as soybeans, peas, chickpeas, dry beans, peanuts, clover, alfalfa, and of non-legumes such as corn, cotton, rice, tomatoes, canola, wheat, barley, sugar beet, and grass. In general, for seed treatment, the composition is applied to seeds in a single application, and the seeds may be planted immediately or stored before planting. The composition may be applied to foliage. Foliar application generally consists of spraying the composition on the plant foliage one or more times during the growing period. In addition, if the flavonoid compound and LCO are applied sequentially, the flavonoid compound may be applied to seeds and the LCO to foliage.

EXAMPLES

1. Soybean (Northrup King S24-k4) Foliar Treatment with LCO+Chitin/Chitosan

A soybean field trial was conducted to evaluate the effects of an LCO and two commercial chitosan products on grain yield when applied to foliage alone or in combination. The two commercial chitosan products utilized in the trial were BEYOND™ (Agri-House Inc., 307 Welch Ave, Berthoud, Colo.), and ELEXA®-4PDB (Plant Defense Boosters, 235 Harrison St, Syracuse, N.Y.). The exact chitin/chitosan concentration in BEYOND™ is unknown, but is estimated to be in the range of 6-12% w/v chitosan and 0-3% w/v chitin, based on U.S. Pat. No. 6,193,988. The chitosan concentration in ELEXA®-4PDB is 4% w/v. ELEXA®-4PDB does not contain chitin. The chitosan concentration in ELEXA®-4PDB is 4% w/v. The LCO product was produced by *Rhizobium leguminosarum* by viceae and contained approximately 1×10^{-8} M LCO. The field trial was located near Whitewater, Wis. at a site characterized by Milford silty clay loam soil. The soil had a pH of 6.6, an organic matter content of 4.8%, and phosphorus and potassium contents of 41 ppm and 131 ppm, respectively.

The soybean seed used in the study was Northrup King variety S24-K4. The LCO treatment was applied by spraying onto foliage at the V4 growth stage (see Soybean Growth and Development, Iowa State University Extension Bulletin PM 1945, May 2004), at a rate of 1 quart/acre in 25 gallons of water. BEYOND™ was diluted to a concentration of 0.132% w/v and ELEXA®-4PDB to 2.5% w/v in water. Each product was applied by spraying onto foliage at a rate of 1 quart/acre in 25 gallons of water. When the LCO-chitin/chitosan combination was applied, the same concentrations of LCO and chitin/chitosan products were used as when each product was applied alone.

The study was conducted in a randomized complete block design, with a plot size of 10 feet by 50 feet, 30 inch row spacing. Four replications were performed. Seeds were planted at a depth of 1 inch and a seeding rate of 175,000 seeds per acre using a John Deere 750 NT grain drill.

Results of this study are shown in Table 1. The LCO, BEYOND™, and ELEXA®-4PDB products each significantly increased grain yield by 3.5, 6.6, and 5.0 bu/acre, respectively, when applied to foliage as stand-alone treatments (p=0.1). Application of ELEXA®-4PDB in combination with LCO statistically increased yield by 6.2 bu/acre over LCO alone and 4.7 bu/acre over ELEXA®-4PDB alone. Application of BEYOND™ in combination with LCO statistically increased yield by 5.3 bu/acre over LCO alone, and numerically increased yield by 2.2 bu/acre over BEYOND™ alone.

Treatment with LCO +ELEXA®-4PDB increased yield compared to the control by 9.7 bu/acre, showing an unexpected synergistic effect of the combination compared with LCO or ELEXA®-4PDB treatment alone.

TABLE 1

Treatment	Grain yield (bu/acre)
Control - non-treated	56.2
LCO	59.7
BEYOND ™	62.8
ELEXA ®-4PDB4 PDB	61.2
LCO + BEYOND ™	65.0
LCO + ELEXA ®-4PDB	65.9
Probability %	<0.1
LSD 10%	2.6
CV %	3.5

2. Soybean (Dairyland DSR 2300SR) Foliar Treatment with LCO+Chitosan

A soybean field trial was conducted to evaluate the effects of an LCO and a commercial chitosan product on grain yield when applied to foliage alone or in combination. The LCO product was the same as that used in Example 1. The com-

mercial chitosan product utilized in the trial was ELEXA®-4PDB. The field trial was located near Whitewater, Wis. at a site characterized by Milford silty clay loam soil. The soil had a pH of 6.8, an organic matter content of 4.8%, and phosphorus and potassium contents of 46 ppm and 144 ppm, respectively.

The soybean seed used in the study was Dairyland variety DSR 2300RR. The study was conducted in a randomized complete block design, with a plot size of 10 feet by 50 feet and 15 inch row spacing. Four replications were performed. Seeds were planted at a depth of 1 inch at a seeding rate of 185,000 seeds per acre using a John Deere 750 NT grain drill.

Both LCO and ELEXA®-4PDB treatments were applied by spraying onto foliage at the V4 growth stage (see Soybean Growth and Development, *Iowa State University Extension Bulletin PM* 1945, May 2004), at a rate of 1 quart/acre in 25 gallons of water using a International Harvester Cub plot sprayer at a ground speed of 2.5 mph. When the LCO-chitosan combination was applied, the same concentrations of LCO and chitosan products were used as when each product was applied alone.

Results of this study are shown in Table 2. The LCO and ELEXA®-4PDB products numerically increased grain yield by 1.7 and 0.6 bu/acre, respectively, when applied to foliage as stand-alone treatments (p=0.1). Application of ELEXA®-4PDB in combination with LCO numerically increased yield by 0.8 bu/acre over LCO alone and 1.9 bu/acre over ELEXA®-4PDB alone. The 2.5 bu/acre increase with the combined LCO and ELEXA®-4PDB exceeded the combined benefit of the individual products alone, showing an unexpected synergistic effect of the combination.

TABLE 2

Treatment	Grain yield (bu/acre)
Control - nontreated	63.2
LCO	64.9
ELEXA ®-4PDB4 PDB	63.8
LCO + ELEXA ®-4PDB	65.7
Probability %	<0.1
LSD 10%	3.9
CV %	5.3

3. Soybean Seed (Dairyland DSR 234RR) Treatment with LCO+Chitin/Chitosan

A soybean field trial was conducted to evaluate the effect of an LCO and two different commercial chitin/chitosan products on grain yield when applied on seed either alone or in combination. The field trial site was located near Whitewater, Wis. and characterized by Milford silty clay loam soil. Soil testing showed a soil pH of 6.8, an organic matter content of 5.1%, and phosphorus and potassium contents of 37 ppm and 136 ppm, respectively.

The LCO product used in the trial (OPTIMIZE®, EMD Crop BioScience) was produced by *Bradyrhizobium japonicum* and contained approximately 1×10^{-9} M LCO. The two commercial chitosan products utilized in the trial were the same as those used in Example 1. The soybean seed used in the study was Dairyland variety DSR 234RR. The LCO product was sprayed onto seeds without dilution at a rate of 4.25 fl oz/cwt. BEYOND™ was diluted to 0.132% w/v and ELEXA®-4PDB to 2.5% w/v with water. Each was applied on seed at the rate of 4.25 fl oz/cwt. When the LCO-chitin/chitosan combination was applied, the same concentrations of LCO and chitin/chitosan products were used as when each product was applied alone. The combined composition was applied at 4.25 fl oz/cwt.

The study was conducted in a randomized complete block design, with a plot size of 10 feet by 50 feet, 7.5 inch row spacing. Four replications were conducted. Seeds were treated just prior to planting and were planted at a depth of 1 inch and a seeding rate of 225,000 seeds per acre using a John Deere 750 NT grain drill.

Results of the study are shown in Table 3, below. The LCO treatment numerically increased grain yield by 2.0 bu/acre relative to the non-treated control group (p=0.1). The chitosan products, BEYOND™ and ELEXA®-4PDB, each provided statistically significant increases of 2.5 and 3.4 bu/acre, respectively, over the non-treated control group. The combination of LCO and BEYOND™ significantly increased yield by 2.3 bu/acre relative to the LCO treatment alone, and numerically increased yield by 1.8 bu/acre compared to the BEYOND™ treatment alone. Treatment with a combination of LCO and ELEXA®-4PDB significantly increased yield by 2.3 bu/acre compared to the LCO treatment alone and numerically increased yield by 0.9 bu/acre relative to ELEXA®-4PDB treatment alone.

TABLE 3

Treatment	Grain yield (bu/acre)
Control - non-treated	55.5
LCO	57.5
BEYOND ™	58.0
ELEXA ®-4PDB4 PDB	58.9
LCO + BEYOND ™	59.8
LCO + ELEXA ®-4PDB	59.8
Probability %	9.6
LSD 10%	2.3
CV %	3.3

4. Corn Seed (Shur Grow SG-686-RR) Treatment with LCO+Chitin/Chitosan

A corn field trial was conducted to evaluate the effects of an LCO and commercial chitosan product on grain yield when applied on seed either alone or in combination. The field trial site was located near Marysville, Ohio and characterized by Blount silt loam soil. Soil testing showed a soil pH of 6.2 and an organic matter content of 2.7%. The field was disk cultivated in the spring prior to planting.

The LCO product used in the trial was the same as that used in Example 1. The commercial chitosan product utilized in the trial was ELEXA®-4PDB.

The corn seed used in the study was Shur Grow hybrid SG-686-RR. The seed was commercially treated with a combination of Maxim XL (0.167 fl oz/cwt, Apron XL (0.32 fl oz/cwt) and Actellic (0.03 fl oz/cwt). When used alone, the LCO product was sprayed on seed without dilution at a rate of 15 fl oz/cwt. The use rate for the chitosan product was 0.375 fl oz/cwt. The product was diluted with water and applied on seed at a slurry rate of 15 fl oz/cwt. When applied in combination, the LCO was applied at $1/10^{th}$ rate of 1.5 fl oz/cwt and the chitosan at a rate of 0.375 fl oz/cwt. The combined products were diluted with water and applied on seed at a slurry rate of 15 fl oz/cwt.

The study was conducted in a randomized complete block design, with four replications and a plot size of 10 feet by 20 feet, and 30 inch row spacing. Seeds were treated just prior to planting and planted at a depth of 1.5 inch and a seeding rate of 28,000 seeds per acre.

Results of the study are shown in Table 4. The LCO and chitosan treatments significantly increased yield 18.6 and 16.9 bu/acre, respectively, relative to the non-treated control group (p=0.1). In contrast, the combined LCO+chitosan

treatment significantly increased yield by 40.0 bu/acre. This increase in yield was significantly greater than the individual treatments, and exceeded the combined benefit of the of the individual LCO and chitosan treatments.

TABLE 4

Treatment	Grain yield (bu/acre)
Control - nontreated	116.9
LCO	135.5
ELEXA ®-4PDB4 PDB	133.8
LCO + ELEXA ®-4PDB	156.9
Probability %	0.0001
LSD 10%	9.3
CV %	5.3

5. Corn Seed (Dairyland DSR-8194) Treatment with LCO+ Chitin/Chitosan

A corn field trial was conducted to evaluate the effects of the *Rhizobium leguminosarum* by viceae-based LCO and the two chitosan products referenced in Example 1 on grain yield when applied on corn seed alone or in combination. The field trial was conducted at a location near Whitewater, Wis., characterized by Milford silty clay loam soil. The soil had a pH of 6.5, an organic matter content of 4.5%, and phosphorus and potassium contents of 40 and 142 ppm, respectively.

Dairyland variety DSR 8194 YGPL corn seed was used in the study. The LCO product was applied without dilution on seed at a rate of 15.3 fl oz/cwt. BEYOND™ was diluted to a concentration of 0.132% w/v and ELEXA®-4PDB 2.5% w/v with water. Each was applied by spraying on seed at the rate of 15.3 fl oz/cwt. When the LCO-chitin/chitosan combination was applied, the same concentrations of LCO and chitin/chitosan products were used as when each of these products was applied alone.

The study was conducted in a randomized complete block design, with a plot size of 15 feet by 50 feet, 30 inch row spacing. Four replications were performed. Seeds were treated just prior to planting and were planted at a depth of 2" at a seeding rate of 33,000 seeds per acre. Seeds were planted with a John Deere Max Emerge II NT 6-row corn planter. Starter fertilizer (7-21-7) was applied at a rate of 200 lb/acre, with a subsequent application of 160 units nitrogen as 28% nitrogen.

The results are shown in Table 5. LCO treatment significantly increased grain yield by 4.6 bu/acre relative to the non-treated control group (p=0.1). Seeds treated with the BEYOND™ product alone showed a numerical yield increase of 3.7 bu/acre, while seed treatment with ELEXA®-4PDB alone showed no effect on grain yield. Combined treatment with LCO and BEYOND™ numerically increased grain yield by 2.1 bu/acre over LCO alone and 3.0 bu/acre over BEYOND™ alone.

Combined treatment with LCO and ELEXA®-4PDB significantly increased grain yield by 8.4 bu/acre compared with ELEXA®-4PDB treatment alone, and numerically increased grain yield by 3.7 bu/acre compared with LCO treatment alone. The LCO and ELEXA®-4PDB combination increased yield to a greater extent than the additive effects of LCO or ELEXA®-4PDB treatment alone, showing a synergistic effect of the combined treatment.

TABLE 5

Treatment	Grain yield (bu/acre)
Control - non-treated	162.1
LCO	166.7
BEYOND ™	165.8
ELEXA ®-4PDB4 PDB	162.0
LCO + BEYOND ™	168.8
LCO + ELEXA ®-4PDB	170.4
Probability %	<0.1
LSD 10%	3.9
CV %	2.0

6. Corn (Jung 6573RR/YGPL) Foliar Treatment with LCO+ Chitin/Chitosan

A corn field trial was conducted evaluating the effect of the *Rhizobium leguminosarum* by viceae-based LCO and the two chitosan products described in Example 1 on grain yield when applied as a foliar application alone or in combination. The field trial was located near Whitewater, Wis. at a site with Milford silty clay loam soil. The soil had a pH of 6.5, and soil test results showed an organic matter content of 4.5%, and phosphorus and potassium contents of 40 and 142 ppm, respectively.

The corn seed used in the study was Jung variety 6573RR/YGPL. The LCO product was applied on the foliage at the V4 growth stage at a rate of 1 quart/acre in 25 gallons of water. BEYOND™ and ELEXA®-4PDB were diluted to concentrations of 0.132% w/v and 2.5% w/v, respectively, in water and applied on foliage at a rate of 25 gallons/acre. When the LCO-chitin/chitosan combination was applied, the same concentrations of LCO and chitin/chitosan products were used as when each of these products was applied alone.

The study was conducted in a randomized complete block design with a plot size of 15 feet by 50 feet, 30 inch row spacing. Four replications were performed. Seeds were planted at a depth of 2 inches and a seeding rate of 33,000 seeds per acre using a John Deere Max Emerge II NT 6-row corn planter. Starter fertilizer (7-21-7) was applied at a rate of 200 lb/acre, with a subsequent application of 160 units nitrogen as 28% nitrogen.

Results of this study are shown in Table 6. The LCO, BEYOND™, and ELEXA®-4PDB products significantly increased grain yield over the non-treated control group by 11.3, 8.8, and 7.4 bu/acre, respectively, when applied to foliage as stand-alone treatments (p=0.1). Application of ELEXA®-4PDB in combination with LCO further increased yield by 1.1 bu/acre compared with ELEXA®-4PDB alone, and 5.0 bu/acre compared with LCO alone. Application of BEYOND' in combination with LCO further increased yield by 2.3 bu/acre compared with LCO alone, and 4.8 bu/acre compared with BEYOND™ alone.

TABLE 6

Treatment	Grain yield (bu/acre)
Control - non-treated	162.6
LCO	173.9
BEYOND ™	171.4
ELEXA ®-4PDB4 PDB	170.0
LCO + BEYOND ™	176.2
LCO + ELEXA ®-4PDB	175.0
Probability %	0.3
LSD 10%	6.5
CV %	3.2

7. Corn Seed (Pioneer 38H52) Treatment with LCO+Flavonoid

A corn field trial was conducted evaluating the effect of liquid formulations of LCO and flavonoid on grain yield when applied alone or in combination on seed. The field trial was conducted at a site near Whitewater, Wis. in a Plano silt loam soil. The soil had a pH of 6.5 and soil test results showed an organic matter content of 4.4% and phosphorus and potassium content of 42 and 146 ppm, respectively. The field was previously planted to soybeans. It was fall chisel plowed and field cultivated in the spring prior to planting.

The LCO product used in the trial was the same as that used in Example 1. The flavonoid product used (ReVV®, EMD Crop BioScience) had a 10 mM total flavonoid concentration comprising genistein and daidzein.

The corn seed used in the trial was Pioneer variety 38H52. The use rate for the LCO and flavonoid products were 1.5 and 0.184 fl oz/cwt, respectively. The products were each diluted with water and applied on seed at a slurry rate of 15.3 fl oz/cwt. The LCO/flavonoid combination was applied at the same concentration and slurry rate as when applied alone. The study was conducted in a randomized complete block design, with a plot size of 10 feet by 50 feet, with 30 inch row spacing, and four replications per treatment. Seeds were planted at a depth of 2 inches at a seeding rate of 33,000 seeds per acre. Planting was carried out using a four row precision vacuum planter. One hundred and forty units of nitrogen were applied as urea in advance of planting, and an additional 150 lb of 7-21-7 starter fertilizer was applied at planting.

Results of the study are shown in Table 7. The flavonoid treatment statistically increased grain yield by 5.3 bu/acre, while the LCO treatment numerically increased grain yield by 3.3 bu/acre. Application of the two products in combination resulted in a statistically significant increase in yield over each of the two products administered alone. The increase observed with the combination treatment of 19.2 bu/acre unexpectedly exceeded the combined effect of the individual products alone (8.6 bu/acre) by more than two-fold, demonstrating a synergistic effect of the combination treatment.

TABLE 7

Treatment	Application	Grain yield (bu/acre)
Control	None	142.5
LCO	Seed	145.8
Flavonoid	Seed	147.8
Flavonoid + LCO	Seed	161.7
Probability %		<0.1
LSD 10%		4.2
CV %		4.4

8. Corn Seed (DynaGro 51K74) Treatment with LCO+Flavonoid

A second corn trial was conducted as described in Example 7 at a location near Fergus Falls, Minn., in a nutrient rich loam soil previously planted to soybeans. The LCO and flavonoid products were applied alone or in combination on DynaGro variety 51K74 corn seed. The study was conducted in a randomized complete block design, with a plot size of 10 feet by 20 feet, with 30 inch row spacing, and four replications per treatment.

Results of the study are shown in Table 8. The LCO and flavonoid seed treatments numerically increased grain yield compared to the non-treated control by 7.3 and 15.3 bu/acre, respectively. Application of the two products in combination statistically increased yield compared to the control by 24.0 bu/acre, and by 17.1 bu/acre compared to the LCO treatment. The increase in yield observed with the combined treatment exceeded the combined increase in yield from the individual products alone.

TABLE 8

Treatment	Application	Grain yield (bu/acre)
Control	None	141.2
LCO	Seed	148.5
Flavonoid	Seed	156.5
Flavonoid + LCO	Seed	165.2
Probability %		<0.1
LSD 5%		13.9
CV %		6.3

9. Corn (Dairyland DSR 4497) Seed, Furrow, and Foliage Treatment with LCO+Flavonoid

A corn field trial was conducted at the same site described above in Example 7 to evaluate the effect of flavonoid seed treatment on grain yield compared to application of LCO either in the seed furrow at planting or spray-applied as a foliar application. These individual product treatments were additionally compared to flavonoid seed treatment combined with in-furrow LCO application and flavonoid seed treatment combined with foliar LCO application. The LCO and flavonoid products were the same as those used in the prior examples.

The corn seed used in the trial was Dairyland variety DSR 4497. The flavonoid product was applied on seed at the same use rate of 0.184 fl oz/cwt and slurry rate in water of 15.3 fl oz/cwt as in prior examples. The LCO product was applied at planting in the seed furrow at a rate of 1 pint/acre in 5 gallons of water, or spray-applied to foliar surfaces at a rate of 1 qt/acre in 25 gallons of water at the V4 stage of corn development. The seed/furrow and seed/foliar applications were at the same rates for the combination as when applied alone.

The study was conducted in a randomized complete block design, with a plot size of 10 feet by 50 feet, with 30 inch row spacing, and four replications per treatment. Seeds were planted at a depth of 2 inches at a seeding rate of 33,000 seeds per acre. Planting was carried out using a four row precision vacuum planter. One hundred and forty units of nitrogen were applied as urea in advance of planting, and an additional 150 lb of 7-21-7 starter fertilizer was applied at planting.

Results of the study are shown in Table 9. Application of flavonoid on seed and LCO in the seed furrow numerically increased grain yield by 4.3 and 2.6 bu/acre, respectively, compared to the control treatment. In contrast, combined application of the two products on seed and in furrow statistically increased yield by 5.5 bu/acre.

Separate application of flavonoid on seed and LCO as a foliar application resulted in a numerical increase in yield with flavonoid seed treatment of 4.3 bu/acre and a statistically significant increase of 7.4 bu/acre with LCO foliar application. Combined flavonoid seed treatment and LCO foliar application further increased yield by 9.2 bu/acre compared to the control treatment.

TABLE 9

Treatment	Application	Grain yield (bu/acre)
Control	None	173.6
Flavonoid	Seed	177.9
LCO	Furrow	176.0

TABLE 9-continued

Treatment	Application	Grain yield (bu/acre)
LCO	Foliar	181.0
Flavonoid/LCO	Seed, furrow	179.1
Flavonoid/LCO	Seed, foliar	182.8
Probability %		<0.1
LSD 10%		4.9
CV %		5.3

10. Corn (Spangler 5775) Seed, Furrow, and Foliage Treatment with LCO+Flavonoid

A parallel corn field trial was conducted at the same location and with the same treatments and trial design as described in Example 9, but differing in the variety of corn used (Spangler 5775).

Results of the study are shown in Table 10. Application of flavonoid on seed statistically increased grain yield by 7.4 bu/acre compared to the non-treated control, while LCO application in the seed furrow numerically increased grain yield by 3.5 bu/acre. Combined flavonoid seed treatment and LCO furrow application further increased yield by 9.7 bu/acre compared to the control treatment.

Separate application of flavonoid on seed and LCO as a foliar application resulted in a statistically significant increase in yield with flavonoid seed treatment of 7.4 bu/acre (as stated above) and a numerical increase of 1.1 bu/acre with LCO foliar application. Application of the two products in combination resulted in a statistically significant increase in yield greater than that seen for each of the two products alone. Further, the increase observed with the combination treatment (16.2 bu/acre) exceeded the combined effect of the individual products alone (8.5 bu/acre), showing a synergistic effect of the combination treatments.

TABLE 10

Treatment	Application	Grain yield (bu/acre)
Control	None	160.7
Flavonoid	Seed	168.1
LCO	Furrow	164.2
LCO	Foliar	161.8
Flavonoid/LCO	Seed, furrow	170.4
Flavonoid/LCO	Seed, foliar	176.9
Probability %		<0.1
LSD 10%		5.6
CV %		4.8

11. LCO Foliar and Flavonoid Seed Treatment of Soybean (Dairyland DSR 1701)

A soybean field trial was conducted to evaluate the effect of flavonoid seed treatment on grain yield compared to the effect of foliar application of LCO. The individual product treatments were additionally compared to flavonoid seed treatment combined with LCO foliar application. The LCO product, was the same as that used in Example 1, and the flavonoid product was the same as that used in prior examples.

The field trial was conducted at a site near Whitewater, Wis. in a Milford silty clay loam soil. The soil had a pH of 6.5 and soil test results showed an organic matter content of 4.7% and phosphorus and potassium content of 48 and 136 ppm, respectively. The field was no-till and was previously planted to corn.

The soybean seed used in the trial was Dairyland variety DSR 1701. The flavonoid product was applied at a use rate of 0.184 fl oz/cwt and slurry rate in water of 4.25 fl oz/cwt. The LCO product was spray-applied to foliar surfaces at a rate of 1 qt/acre in 25 gallons of water at the V4 stage of soybean development. The combined seed/foliar application was at the same rate as when applied alone. The study was conducted in a randomized complete block design, with a plot size of 10 feet by 50 feet, with 30 inch row spacing, and four replications per treatment. Seeds were planted at a depth of 1 inch at a seeding rate of 160,000 seeds per acre. Planting was carried out using a John Deere 750 NT grain drill.

Results of the study are shown in Table 11. Application of flavonoid on seed statistically increased grain yield by 3.2 bu/acre compared to the non-treated control, while LCO foliar application numerically increased grain yield by 1.2 bu/acre. Application of the two products in combination resulted in a statistically significant increase above each of the two products alone, with the increase in yield (5.0 bu/acre) exceeding the combined effect of the individual products alone (4.4 bu/acre), showing a synergistic effect of the combination treatment.

TABLE 11

Treatment	Application	Grain yield (bu/acre)
Control	None	47.8
Flavonoid	Seed	51.0
LCO	Foliar	49.0
Flavonoid/LCO	Seed/foliar	52.8
Probability %		<0.1
LSD 10%		1.3
CV %		5.2

12. LCO Foliar and Flavonoid Seed Treatment of Soybean (Dairyland DSR 2000)

A parallel soybean field trial was conducted at the same location and with the same treatments and trial design as described in Example 11, but differing in the variety of soybean used (Dairyland variety DSR 2000).

Results of the study are shown in Table 12. Application of flavonoid on seed and LCO as a foliar application statistically increased grain yield by 2.6 and 4.5 bu/acre, respectively, compared to the non-treated control. Combined flavonoid seed treatment and LCO foliar application further increased yield by 7.1 bu/acre compared to the control treatment.

TABLE 12

Treatment	Application	Grain yield (bu/acre)
Control	None	40.9
Flavonoid	Seed	43.5
LCO	Foliar	45.4
Flavonoid/LCO	Seed/foliar	48.0
Probability %		<0.1
LSD 10%		1.8
CV %		4.5

13. Soybean Seed (Dairyland DSR 2300RR) Treatment with LCO+Flavonoid

A soybean field trial was conducted to evaluate the effect of LCO and flavonoid products on grain yield when applied on seed either alone or in combination. The field trial site was located near Whitewater, Wis. and characterized by Plano silt loam soil. Soil testing showed a soil pH of 6.5, an organic matter content of 3.9%, and phosphorus and potassium contents of 40 ppm and 138 ppm, respectively. The field was no-till and was previously planted to corn.

The LCO product used in the trial (OPTIMIZE®, EMD Crop BioScience) was produced by *Bradyrhizobium japonicum* and contained approximately 1×10^{-9} M LCO. The flavonoid product used (ReVV®, EMD Crop BioScience) had a 10 mM total flavonoid concentration comprising genistein and daidzein in a ratio of 8:2 w/w.

The soybean seed used in the study was Dairyland variety DSR 2300RR. The LCO and flavonoid products were sprayed onto seeds alone or in combination at a rate of 4.25 and 0.184 fl oz/cwt, respectively. The study was conducted in a randomized complete block design, with four replications and a plot size of 10 feet by 50 feet, and 15 inch row spacing. Seeds were treated just prior to planting and planted at a depth of 1 inch and a seeding rate of 185,000 seeds per acre using a John Deere 750 NT grain drill.

Results of the study are shown in Table 13. The LCO and flavonoid treatments numerically increased yield 2.9 and 4.0 bu/acre, respectively, relative to the non-treated control group (p=0.1). In contrast, the combined LCO +flavonoid treatment significantly increased yield by 7.0 bu/acre. This increase in yield was greater than the combined benefit of the of the individual LCO and flavonoid treatments.

TABLE 13

Treatment	Grain yield (bu/acre)
Control - nontreated	54.1
LCO	57.0
Flavonoid	58.1
LCO + flavonoid	61.1
Probability %	<0.1
LSD 10%	4.2
CV %	3.6

14. Corn (Pioneer hybrid 34A17) Foliar Treatment with LCO+Flavonoid or LCO+Chitosan

A corn field trial was conducted to evaluate the effects of LCO/flavonoid, and LCO/chitosan products on grain yield when applied to foliage alone or in combination. The LCO product was produced by *Rhizobium leguminosarum* by viceae and contained approximately 10^{-8} M LCO. The flavonoid product used had a 10 mM total flavonoid concentration comprising genistein and daidzein in a ratio of 8:2 w/w. The chitosan product (ELEXA®-4PDB) was the same as that used in the prior examples.

The field trial was located near York, Nebr. at a site characterized by Hastings silt loam soil. The soil had a pH of 6 and an organic matter content of 3%. The site was conventionally tilled, and the prior crop was soybeans. The corn seed used in the study was Pioneer hybrid 34A17. The study was conducted in a randomized complete block design, with a plot size of 10 feet by 30 feet and 30 inch row spacing. Four replications were performed. Seeds were planted at a depth of 2 inches at a seeding rate of 30,200 seeds per acre.

Treatments were applied by spraying onto foliage at the V5 growth stage. The LCO and ELEXA®-4PDB treatments were applied at a rate of 1 quart/acre in 20 gallons of water using a small plot sprayer at a ground speed of 2.3 mph. The flavonoid treatment was initially diluted 25× in water, then applied at a rate of 1 quart/acre in 20 gallons of water. The LCO-chitosan combination treatment was applied at a reduced rate of 3.2 fl oz/acre of LCO and 12.8 fl oz chitosan in 20 gallons of water. For the LCO-flavonoid combination, the flavonoid was first diluted 25× in water, then applied similarly to the LCO-chitosan combination at 3.2+12.8 fl oz/acre diluted in 20 gallons of water.

Results of this study are shown in Table 14. The LCO, flavonoid, and ELEXA®-4PDB treatments numerically increased grain yield by 1.2, 3.5, and 1.5 bu/acre, respectively, when applied to foliage as stand-alone treatments (p=0.1). Combined application of LCO with flavonoid and LCO with ELEXA®-4PDB significantly increased yield by 8.6 and 12.1 bu/acre compared to the control treatment. In each case, the combined treatment response exceeded the combined benefit of the individual products alone, demonstrating a synergistic effect of the combination compositions. This occurred even though the combination products were applied at reduced rates compared to when applied alone.

TABLE 14

Treatment	Grain yield (bu/acre)
Control - nontreated	222.0
LCO	223.2
Flavonoid	225.5
ELEXA ®-4PDB4 PDB	223.5
LCO + flavonoid	230.6
LCO + ELEXA ®-4PDB	234.1
Probability %	0.0909
LSD 10%	6.5
CV %	2.4

15. Corn (Midwest Seed Genetics Hybrid 8463859 RR2) Foliar Treatment with LCO+Flavonoid or LCO+Chitosan

A corn field trial was conducted similar to that of Example 14 to evaluate the effects of LCO/flavonoid, and LCO/chitosan products on grain yield when applied to foliage alone or in combination. The LCO, flavonoid, and chitosan products were the same as that used in Example 14.

The field trial was located near Sparta, Ill. at a site characterized by silt loam soil. The soil had a pH of 6.5 and an organic matter content of 2.6%. The site was conventionally tilled, and the prior crop was soybeans. The corn seed used in the study was Midwest Seed Genetics hybrid 8463859 RR2. The study was conducted in a randomized complete block design, with a plot size of 10 feet by 40 feet and 30 inch row spacing. Four replications were performed. Seeds were planted at a depth of 2 inches at a seeding rate of 26,100 seeds per acre.

Treatments were applied by spraying onto foliage at the V3-V4 growth stage. The individual and combined treatments were applied at the rates described in Example 14 in 20 gallons of water using a backpack sprayer at a ground speed of 3 mph.

Results of this study are shown in Table 15. The LCO, flavonoid, and ELEXA®-4PDB treatments numerically increased grain yield by 3.4, 7.1, and 3.3 bu/acre, respectively, when applied to foliage as stand-alone treatments (p=0.1). Combined application of LCO with flavonoid significantly increased yield by 16.5, while combined application of LCO with ELEXA®-4PDB numerically increased yield by 10.5 bu/acre compared to the control treatment. In each case, the combined treatment response exceeded the combined benefit of the individual products alone, demonstrating a synergistic effect of the combination compositions. This occurred even though the combination products were applied at reduced rate compared to when applied alone.

TABLE 15

Treatment	Grain yield (bu/acre)
Control - nontreated	71.7
LCO	75.1
Flavonoid	78.8
ELEXA ®-4PDB4 PDB	75.0
LCO + flavonoid	88.2
LCO + ELEXA ®-4PDB	82.2
Probability %	0.6459
LSD 10%	13.8
CV %	14.6

applied at the V6 growth stage at the same 1 quart/acre for the LCO and label rate for the herbicide products in 20 gallons of water using a small plot sprayer at a ground speed of 2.3 mph.

Results of this study are shown in Table 16. With the two Whitewater, Wis. trials, application of LCO in combination with the four different herbicides enhanced grain yield compared to the herbicide alone with all LCO/herbicide combinations at the two locations, with the exception of the LCO+ Steadfast combination at the P-1 site. At the York, Nebr. location, application of LCO in combination with the four different herbicides enhanced grain yield compared to the herbicide alone with each of the LCO/herbicide combinations, with the exception of the LCO+Calisto treatment.

TABLE 16

Trial location	Round-Up	LCO + Round-Up 1 qt/A	Liberty	LCO + Liberty 1 qt/A	Calisto	LCO + Calisto 1 qt/A	Steadfast Steadfast	LCO + Steadfast 1 qt/A
Whitewater. WI	157.5	161.9	152.1	156.9	156	158.8	140.6	141.2
Whitewater. WI	161.2	169.2	159.6	164.2	162.8	169.1	154.4	152.1
York, NE	195.8	204.6	201	208.9	202.8	202	194.3	201.3

16. Corn Foliar Treatment with LCO and Herbicide

Three corn field trials were conducted to evaluate the effect of foliar application of LCO in combination with four different herbicides. The LCO is the same as that used in prior foliar application examples. The herbicides included glyphosate (Roundup Original Max®, Monsanto Company, St. Louis, Mo.), glufosinate-ammonium (Liberty®, Bayer CropScience LP, Research Triangle Park, N.C.), mesotrione (Calisto®, Syngenta Crop Protection, Inc., Greensboro, N.C.), and nicosulfu/rimsulfuron (Steadfast®, E. I. du Pont de Nemours and Company, Wilmington, Del.).

Two of the trials were located near Whitewater, Wis. at sites characterized by Milford silty clay loam soil (fields F-5 and P-1). The F-5 site was conventionally tilled with a prior crop of corn, and the P-1 site was minimum tilled with soybean as the prior crop. The corn seed used for both studies was Pioneer hybrid 36B05 HXX/RR/LL. The studies were conducted in a randomized complete block design, with a plot size of 10 feet by 50 feet, 30 inch row spacing, and four replications. Seeds were planted at a depth of 2 inches at a seeding rate of 33,000 seeds per acre using a vacuum precision plot planter.

The third field trial was located near York, Nebr. at a site characterized by Hastings silt loam soil. The site was conventionally tilled with h soybean as the prior crop. The corn seed used in the study was Pioneer hybrid 34A17. The study was conducted in a randomized complete block design, with a plot size of 10 feet by 30 feet, 30 inch row spacing, and four replications. Seeds were planted at a depth of 2 inches at a seeding rate of 30,200 seeds per acre.

Treatments at the two Whitewater, WO sites were applied by spraying onto foliage at the V4 growth stage. The LCO treatment was applied at a rate of 1 quart/acre; the herbicide products were applied at label rate for each product. The herbicide and LCO+herbicide treatments were foliar-applied in 25 gallons of water using a small plot sprayer at a ground speed of 2.5 mph. Treatments at the York, Nebr. site were

Although preferred embodiments of the invention have been shown and described herein, it will be understood that such embodiments are provided by way of example only. Numerous variations, changes and substitutions will occur to those skilled in the art without departing from the spirit of the invention. Accordingly, it is intended that the appended claims cover all such variations as fall within the spirit and scope of the invention.

What is claimed:

1. A composition for enhancing plant growth or crop yield comprising at least one lipo-chitooligosaccharide and one or more chitinous compounds selected from the group consisting of chitins and chitosans.

2. The composition of claim **1**, wherein the lipo-chitooligosaccharide is produced by a bacterium of the bacterial genera selected from the group consisting of *Bradyrhizobium, Rhizobium, Sinorhizobium*, and *Mesorhizobium.*

3. The composition of claim **1**, wherein the lipo-chitooligosaccharide is produced by chemical synthesis.

4. The composition of claim **1**, wherein the lipo-chitooligosaccharide is produced, at least in part, by a genetically modified cell or organism.

5. The composition of claim **1**, wherein the lipo-chitooligosaccharide is present at a concentration of between 10^{-5} M to 10^{-14} M.

6. The composition of claim **5**, wherein the lipo-chitooligosaccha ride is present at a concentration of between 10^{-6} M to 10^{-10} M.

7. The composition of claim **1** further comprising a bacterium that produces an LCO.

8. The composition of claim **1**, wherein the one or more chitinous compounds are chitins.

9. The composition of claim **1**, wherein the one or more chitinous compounds are present at a concentration of between 0.1 to 15% w/v.

10. The composition of claim **9**, wherein the one or more chitinous compounds are present at a concentration of between 3 to 12% w/v.

11. The composition of claim **1**, wherein the composition further comprises at least one flavonoid compound selected from the group consisting of flavones, flavanols, flavonols, flavanones, and isoflavones.

12. The composition of claim **11**, wherein the at least one flavonoid compound is selected from the group consisting of genistein, daidzein, formononetin, naringenin, hesperetin, luteolin, and apigenin.

13. The composition of claim **11**, wherein the flavonoid compound is present at a concentration of between 20 μM to 800 μM.

14. The composition of claim **13**, wherein the flavonoid compound is present at a concentration of between 100 μM to 500 μM.

15. The composition of claim **1**, wherein the composition further comprises at least one herbicidal compound.

16. The composition of claim **15**, wherein the herbicidal compound is selected from the group consisting of bentazon, acifluorfen, chiorimuron, lactofen, clomazone, fluazifop, glufosinate, glyphosate, sethoxydim, imazethapyr, imazamox, fomesafe, flumiclorac, imazaquin, and clethodim.

17. A method for enhancing plant growth or crop yield comprising administering to a plant or seed the composition of claim **1** in an effective amount for enhancing foliar plant growth or crop yield.

18. The composition of claim **1**, wherein the one or more chitinous compounds are chitosans.

19. The method of claim **17**, wherein the plant is selected from the group consisting of soybeans, peas, chickpeas, drybeans, peanuts, clover, alfalfa, corn, cotton, rice, tomatoes, canola, wheat, barley, sugar beet, and grass.

20. The method of claim **17**, wherein the composition is administered by applying the composition to foliage, seeds, or to soil that is in the immediate vicinity of the plant or seed.

21. A method for enhancing plant growth or crop yield comprising administering to a plant or seed a composition comprising at least one lipo-chitooligosaccharide and one or more chitinous compounds selected from the group consisting of chitins and chitosans in an effective amount for enhancing plant growth or crop yield.

22. The method of claim **17**, wherein the plant or seed is a legume.

23. The method of claim **21**, wherein the composition further comprises at least one flavonoid compound selected from the group consisting of genistein, daidzein, formononetin, naringenin, hesperetin, luteolin, and apigenin.

24. The method of claim **21**, wherein the lipo-chitooligosaccharide is present at a concentration of between 10^{-5} M to 10^{-14} M.

25. The method of claim **21**, wherein the one or more chitinous compounds are present at a concentration of between 0.1 to 15% w/v.

26. The method of claim **23**, wherein the flavonoid compound is present at a concentration of between 20 μM to 800 μM.

27. A method for enhancing plant growth or crop yield comprising sequentially administering to a plant or seed, in either order, a first composition comprising at least one lipo-chitooligosaccharide in an effective amount for enhancing plant growth or crop yield, and a second composition comprising at least one chitinous compound in an effective amount for enhancing plant growth or crop yield, wherein the at least one chitinous compound is selected from the group consisting of chitins and chitosans.

28. The method of claim **27**, wherein the lipo-chitooligosaccharide is present at a concentration of between 10^{-5} M to 10^{-14} M.

29. The method of claim **27**, wherein the one or more chitinous compounds are present at a concentration of between 0.1 to 15% w/v.

30. The method of claim **17**, wherein the plant or seed is a non-legume.

31. The method of claim **21**, wherein the composition further comprises at least one herbicide, wherein the composition is applied to a plant that is genetically modified for resistance to the at least one herbicide.

* * * * *

CERTIFICATE OF FILING AND SERVICE

On the 8th day of December 2014, I served a true and correct copy of the foregoing Brief and it's Addendum on counsel for Defendant through the Court's ECF system, which will send notice of such filing to the following registered CM/ECF users:

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I further certify that, upon acceptance and request from the Court, the required paper copies of the foregoing will be deposited with United Parcel Service for delivery to the Clerk, United States Court of Appeals for the Federal Circuit, 717 Madison Place, NW, Washington, DC 20439.

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Dated: December 8, 2014

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